

IN THIS ISSUE

Garrett Crow and Dave Warners continue their series of studies of the Grand Rapids area flora inspired by the pioneering work of Emma Cole's 1901 *Grand Rapids Flora*. This is the sixth entry in the series, several of which have included student authors in important roles. It is also the second article in the series that reports on botanical assessments of parcels in the Lowell Regional Greenspace, which is under development as park and recreational areas by Kent County Parks. The first of the two articles assessed high-quality woodland parcels in the Greenspace, while this article assesses high-quality shrub-carr and hardwood swamp wetlands.

It is not often that species new to science are discovered in the Great Lakes region. The second article in this issue is the second report of a new species of goldenrod (*Solidago*) from Michigan to be published in the pages of this journal. The first was the description of *Solidago vossii* Pringle & Laureto (Voss's Goldenrod) in 2010. Now, Jess Peirson, who has been studying the coastal dune goldenrods in Michigan for some time, describes a new species from the dunes along the southern shore of Lake Superior in Michigan's Upper Peninsula. In addition to a thorough description of the new species and its habitat and an account of its relationships with near relatives, the article also includes notes on other endemic taxa of *Solidago* in the Great Lakes region and an updated key to all species of *Solidago* in Michigan. For this purpose, the species sometimes segregated into the genus *Oligoneuron* are retained in *Solidago*.

Harvey Ballard, an authority on the genus *Viola*, reports the second occurrence of *Viola epipsila* (Dwarf Marsh Violet) in the eastern United States. Expanding on the usual format for Noteworthy Collections articles, the author provides a detailed and informative discussion of the taxonomic relationships of this species and its relatives.

This issue concludes with reviews of two recent books, *Wildflowers of the Indiana Dunes National Park*, published earlier this year, and *Botany for the Artist*. The Indiana Dunes National Park, located on the southern shore of Lake Michigan and which was upgraded from a National Lakeshore just a couple of years ago, is one of the floristically richest units in the National Park system as well as in the Great Lakes area. This new wildflower guide provides for the first time a thorough guide to the commonly encountered species of the Park and should also be useful throughout the greater Chicago area. *Botany for the Artist* instructs the reader not only in drawing techniques but in the necessary visual aspects of botanical structure, thereby assisting the artist in *seeing* the object of the art in a special way.

—Michael Huft

BOTANICAL ASSESSMENTS OF HIGH-QUALITY SOUTHERN SHRUB-CARR AND HARDWOOD SWAMP WETLANDS IN THE UNDEVELOPED LOWELL REGIONAL GREENSPACE, KENT COUNTY, MICHIGAN

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ABSTRACT

The 2019–2023 Masterplan for Kent County Parks includes the future development of acquired properties that have been designated as the Lowell Regional Greenspace (528 acres), occupying nearly the entirety of Section 22 of Lowell Charter Township in Kent County, Michigan. Four wetlands located in the same drainage basin along Karen Creek in the Lowell Regional Greenspace were inventoried for floristic quality assessments during the summers of 2016, 2018, 2019, and 2021. One of the wetlands was forested and determined to be a southern hardwood swamp community type. The other three wetlands are best classified as shrub-carr communities. In the southern hardwood swamp, we recorded 94 species, of which 87 (92%) are native. A total of 321 species were documented in the three shrub-carrs wetlands combined. The number of species in each shrub-carr site, ranging from 172 to 238, is roughly twice that for the southern hardwood swamp site. Two of the species documented are listed as Special Concern in Michigan, and two are new county records for Kent County, Michigan. A non-metric multidimensional scaling model (NMDS) was run to spatially compare similarities and differences among the sites. The Sørensen Index of Similarity, which was employed to further discern differences between pairs of individual sites, was also useful for assigning plant community types as described by the Michigan Natural Features Inventory (2016). The Floristic Quality Assessments indicate that all four of the wetlands are floristically important statewide; furthermore, the three shrub-carr communities have exceptional conservation value. We discovered that the three shrub-carr sites have a high degree of similarity in their species assemblages, whereas the southern hardwood swamp was markedly different. The high richness and significant floristic quality of the shrub-carr sites highlight the conservation value of these often-overlooked habitats. This study underscores the importance of preserving even small tracts of persisting remnant natural habitats. Our research should be of use to Kent County Parks as they approach development of the Lowell Regional Greenspace into a multiple-use recreational space, as well as to those interested in learning more about how to assess and compare habitat quality of remnant natural areas.

KEYWORDS: Michigan flora, biodiversity, shrub-carr, southern hardwood swamp, Floristic Quality Assessment, floristic inventory.

INTRODUCTION

A legal wetland definition provided by the U. S. Army Corps of Engineers (1987) states: “Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in

saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.” Although formal definitions have been developed by scientists and federal agencies, Mitsch and Gosselink (2015) note that the ecotonal nature between terrestrial and aquatic systems renders wetlands not easily defined. Furthermore, the wetland delineation manual prepared by the U. S. Army Corps of Engineers (1987, 2012) states that the definition of the term “wetland” is, of necessity, a broad term and notes that the wetland delineation manual does not specifically function as a classification system of wetland communities.

Defining a specific wetland community can be challenging because wetlands encompass a variety of ecosystems that do not always segregate easily. In the Great Lakes Region, forested wetlands range from bottomland hardwood swamps to floodplain forests to conifer swamps. Open, non-forested wetlands are abundant and diverse, ranging from acidic bogs to wet meadows, marshes and calcareous fens. Ecologically positioned somewhere between these extremes are wetlands that are dominated by shrubs. The nomenclature itself for shrub-dominated wetlands can be confusing (Curtis 1959; Davis 1979; Jenik and Větvicka 2002; Jenik et al. 2002). Of the 28 wetland communities listed by the Michigan Natural Features Inventory, three are shrubby wetlands, each of which is given a different habitat name: inundated shrub swamp, northern shrub thicket, and southern shrub-carr (Cohen et al. 2015). In this paper we use the term “shrub-carr” to refer to shrub-dominated wetlands, and we use the term “swamp” to refer to wetlands that are dominated by trees.

Another source of confusion is that species assemblages can vary widely even within a particular wetland community type (Jolman et al. 2019). This is certainly true of shrub-carrs, where the dominant woody species can differ between individual sites. In northern latitudes, shrub-carrs are often dominated by speckled alder (*Alnus incana*). Elsewhere shrub-carrs can support a shrub matrix dominated by species of *Salix* (including *Salix cinerea*, *S. discolor*, and/or others) or *Cornus* (including *Cornus amomum*, *C. racemosa*, and/or *C. sericea*), and some shrub-carrs are populated by a mixture of shrubby species without a clear dominant. Secondary woody species in shrub-carrs may include black chokeberry (*Aronia prunifolia*), bog birch (*Betula pumila*), spicebush (*Lindera benzoin*), wild black currant (*Ribes americanum*), American red raspberry (*Rubus strigosus*), elderberry (*Sambucus canadensis*), poison sumac (*Toxicodendron vernix*), highbush blueberry (*Vaccinium corymbosum*), nannyberry (*Viburnum lentago*), or the non-native glossy buckthorn (*Frangula alnus*) (Eggers and Reed 2015; Crum 1992; Davis 1979; Cohen et al. 2015; Květ et al. 2002).

Additionally, shrub-carrs are often habitats in flux, involved in the slow process of transitioning from more open sedge meadows or fens into shadier, woody-dominated habitats (Curtis 1959; Jeník and Větvická 2002; Jeník et al. 2002; White 1965). The successional stage of a site will influence the density of the shrub layer, the availability of light, and moisture conditions. These factors will in turn affect the richness and composition of the herbaceous matrix (Eggers and Reed 2015; White 1965). Typically, a combination of wetland ferns, forbs, vines, grasses, and sedges contribute to a shrub-carr groundcover. The wide variability of environmental conditions that are possible in even a single shrub-carr can contribute to high floristic richness in these communities, particularly in

shrub-carrs that have experienced minimal direct human disturbance (Curtis 1959; Eggers and Reed 2015; White 1965).

Although variability is inherent among shrub-carr communities, a general definition is that these are wetlands dominated by tall, deciduous shrubs reaching an average height of 1.5–3.0 meters (Eggers and Reed 2015; Cohen et al. 2015). They usually occur on either saturated or seasonally flooded soils and are impacted by fluctuating water levels (Cohen et al. 2015; Květ et al. 2002). Shrubs usually account for more than 50 percent of the cover in shrub-carrs, in some sites reaching as high as 95 percent (Curtis 1959; Cohen et al. 2015). The herbaceous vegetation in shrub-carrs includes a combination of heliophytic wet meadow and shade-tolerant species (Curtis 1959).

Most shrub-carrs are ecosystems that have been subjected to and influenced by disturbance (Ruch et al. 2009). Authors have historically disagreed about the relative importance of disturbance in shrub-carrs and whether these communities are naturally occurring or if they appear only in the aftermath of disturbance. Indeed, fire suppression and wetland drainage have both been associated with advancing the presence of shrubs in otherwise herbaceous wetlands such as sedge meadows or fens (Warners 1989, 1997; Eggers and Reed 2015). Other studies have documented that repeated disturbances like grazing or mowing also promote shrub cover (Middleton 2002; Jeník and Větvická 2002; Jeník et al. 2002). And yet, whatever their origin, shrub-carrs are relatively common ecological features in the Great Lakes region and can serve as important refuges for native biodiversity.

The purpose of this paper is to document and compare four wetlands that occur in close proximity along Karen Creek in Lowell Township, Kent County, Michigan. Three of these wetlands fit the above definition of shrub-carr, and the fourth is clearly a southern hardwood swamp, dominated by silver maple (*Acer saccharinum*). The property containing three of these wetlands was recently acquired by the Kent County Parks Department as the Lowell Regional Green-space, and the fourth is part of the Land Conservancy of West Michigan's B. D. White Preserve. All four wetlands are less than four hectares in size (Table 1). By conducting thorough floristic inventories of each wetland, assessing similarities and differences in their species assemblages, and calculating metrics of floristic quality for each wetland, we aim to contribute a better understanding of the shrub-carr association in Michigan. Additionally, we aim to demonstrate the contribution that these wetland types make to the state's native biodiversity and highlight the similarities and differences among shrub-carrs and between shrub-carrs and a southern hardwood swamp. Furthermore, this work will generate management considerations for the Kent County Parks Department and others who are tasked with managing shrub-carr habitats.

MATERIALS AND METHODS

General Site Description

The Kent County Parks Masterplan 2019–2023 (Kent County Parks 2021) includes development and further acquisition of properties occupying nearly the entirety of section 22 in Lowell Charter Township (Warners et al. 2021). This currently undeveloped land, referred to as the Lowell Regional

TABLE 1. Floristic Quality Assessment metrics for the four wetland sites. Data for the B. D. White Shrub-Carr from Stockdale et al. (2019) combined with unpublished data from J. Heslinga, Land Conservancy of West Michigan.

Site Name (Wetland Community Type)	Area hectares (acres)	Total FQI	Native FQI	Total Mean C	Native Mean C	Number of Species	Number of Native Species (percentage)	Number of Non-Native Species (percentage)
Silver Maple Swamp (Southern hardwood swamp)	1.33 ha (3.28)	36.8	38.2	3.8	4.1	94	87 (92.6%)	8 (7.4%)
East Wetland (Southern shrub-carr)	1.68 ha (4.15)	52.5	55.8	4.0	4.5	172	154 (89.5%)	18 (10.5%)
West Wetland (Southern shrub-carr)	3.71 ha (9.18)	63.3	65.4	4.1	4.4	238	221 (92.9%)	17 (7.1%)
B. D. White Shrub-Carr (Southern shrub-carr)	3.48 ha (8.59)	55.4	56.3	4.0	4.2	192	180 (93.8%)	12 (6.3%)

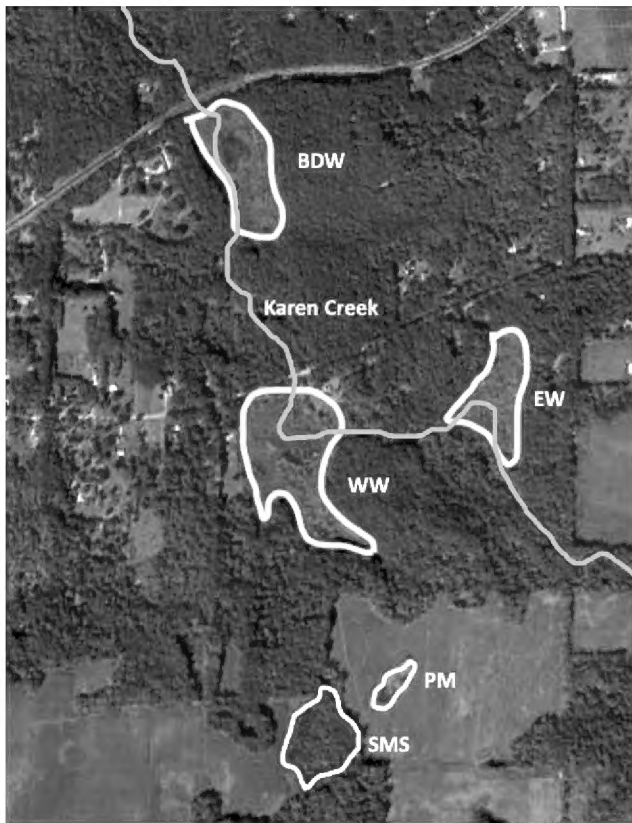


FIGURE 1. Lowell Regional Greenspace wetlands: EW = East Wetland (southern shrub-carr); WW = West Wetland (southern shrub-carr); SMS = Silver Maple Swamp (southern hardwood swamp forest); PM = Prairie Pond/Marsh. Bradford Dickinson White Preserve wetland: BDW = B. D. White Shrub-Carr (southern shrub-carr). (Image: 9/25/2014; source: Google Earth).

Greenspace, is bounded on the north by 36th Street, on the south by Cascade Road, on the east by Segwun Avenue, and on the west by Alden Nash Avenue. The property is contiguous to the B. D. White Preserve, located on the north side of 36th Street and owned and actively managed by the Land Conservancy of West Michigan. The B. D. White Preserve has an extensive southern shrub-carr (which we will refer to as the B. D. White Shrub-Carr; Figure 1: BDW), fed by the same stream, Karen Creek, that flows through the Lowell Regional Greenspace. This downstream shrub-carr was inventoried in 2016 and described and reported in our earlier study (Stockdale et al. 2019). It is included in the current assessment because it is part of the same drainage system as the wetlands in the Lowell Regional Greenspace. The other three wetlands included in this assessment are as follows.

The East Wetland (Figure 1: EW) lies toward the northeastern portion of the Lowell Regional Greenspace property. This wetland is situated in a broad basin and is fed by seepage as well as by Karen Creek, which flows into the basin from a steep-sided ravine after originating approximately 0.5 km upstream from springs and seeps. The creek meanders northward through the southern portion of East Wetland, then flows westward, exiting the wetland and flowing through a wooded parcel known as North Woods before entering West Wetland (Warners et al. 2021).

The West Wetland (Figure 1: WW) is bordered on its north end by 36th Street. This open shrubby wetland is fed by Karen Creek and by springs that emerge from the base of a steep slope that supports a track of old growth forest. There are also intermittent tributaries that flow off other surrounding wooded slopes, contributing surface flow to the wetland especially during rain events. Karen Creek enters West Wetland on the east side, and eventually meanders to the north. The creek then crosses under 36th Street via a culvert, flowing northward into the B. D. White Preserve. After passing through forested areas for about 0.5 km, the creek enters B. D. White Shrub-Carr (see Stockdale et al. 2019).

The Silver Maple Swamp (Figure 1: SMS), a southern hardwood swamp dominated by silver maple trees (*Acer saccharinum*), is curiously perched about 30 m higher in elevation than the Karen Creek lowlands. This swamp is located approximately 0.25 km due south of West Wetland and is situated between two mature upland hardwood forests. This ecosystem is likely underlain by an impervious clay lens or hardpan, above which has accumulated a relatively thin layer of muck (Cohen et al. 2015). On each of our visits (7 times in 2021 alone) this site had standing water. The large trees, both standing and fallen, together with a rich assemblage of ferns and mosses give it a primeval appearance. We included this wetland in our assessment both to offer a contrast to the nearby East Wet-

land and West Wetland and to provide a detailed description for Kent County Parks as they make plans to manage all of these natural areas.

Botanical Inventory

During the growing seasons of mid-March through mid-September of 2018, 2019, and 2021, botanical inventories were conducted to assess the wetlands in the Lowell Regional Greenspace. Sampling protocol for all sites was a meander-search throughout, conducted multiple times over the course of the three growing seasons. All species encountered were documented by voucher herbarium specimens or recorded as photo or sight records. During each visit all species in flower or fruit were identified primarily using Voss and Reznicek (2012), as well as Barnes and Wagner (2004), Crow and Hellquist (2000a, 2000b), and the Internet online sources MICHIGAN FLORA ONLINE (2011) and keys at Go Botany (Native Plant Trust 2019). Identifications and nomenclature follow that of MICHIGAN FLORA ONLINE (2011), as this source includes both seed plants, based on Voss and Reznicek (2012) and pteridophytes, based on Palmer (2019); the online source is periodically updated with taxonomic and nomenclatural changes. A total of 540 herbarium voucher specimens documenting the study were deposited in the Calvin University Herbarium (CALVIN), and duplicates are deposited in the herbaria of Michigan State University (MSC) and/or University of Michigan (MICH). A similar approach was used to inventory the B. D. White Shrub-Carr in 2016, with details described in Stockdale et al. (2019).

Floristic Quality Assessments

Floristic Quality Assessments provide useful metric-based measures to evaluate habitat conservation priorities and have become increasingly influential in North America over the past 20 years (Spyreas 2019). Floristic Quality Assessments are based on the *C*-value of each species in the area under investigation. Plants with *C*-values of 8–10 (high *C*-values) have a very strong affinity to a narrow range of undisturbed ecological conditions, whereas *C*-values of 0–2 are associated with more widespread, disturbance-tolerant species that can be found growing in a wide range of habitats. A Floristic Quality Index (FQI) provides a reliable estimate of the natural quality of an area and can be used to compare the ecological integrity of different landscapes (Bried et al. 2013). The Universal FQA Calculator (<https://universalfq.org/>) (Freyman et al. 2015) generates both a Native FQI and a Total FQI, the former based only on the native species that are present and the latter based on both native and non-native species combined. Inclusion of non-native species (*C*-values = 0) results in a Total FQI which is lower than the Native FQI; the difference between the two indicates the relative impact of non-native species. Herman et al. (2001) have set FQA thresholds, suggesting that sites with Native FQI thresholds of 35 or higher are generally valued as floristically important statewide. FQI scores greater than 50 suggest exceptional sites that exhibit extremely high conservation value.

The Universal FQA Calculator (Freyman et al. 2015) also generates a Mean *C*-value, the average *C*-value for all species within the site assessed, including non-native species, and is then referred to as the Total Mean *C*. A Native Mean *C* is also calculated, reflective of the site's native species richness. These FQA metrics are used variously by state and federal agencies and conservation organizations to evaluate natural areas and inform land management strategies. The Native Mean *C* for the entire state of Michigan is 6.5, based on 1814 native species (2912 spp. total) (Reznicek et al., 2014). Matthews et al. (2005) and Slaughter et al. (2015), while recognizing that a site's FQI values are useful, feel that the Mean *C*-value represents a less biased indicator of relative conservation value. We have found both metrics to be helpful for practitioners involved in ecological integrity assessments, so we provide both in this report.

Non-metric Multidimensional Ordination (NMDS)

A non-metric multidimensional scaling model (NMDS) was run on presence/absence floristic data to spatially analyze similarities and differences among the four wetlands. Jaccard's dissimilarity metric is especially helpful in comparing binary data. To run the NMDS, R version 4.4.1 (R Core Team 2020) was used with the package's *vegan* (Oksanen et al. 2020) and *MASS* (Venables and Ripley 2002) options. The ordination was created using the *ggplot2* (Wickham 2016) and *cowplot* (Wilke 2020) packages. A post-hoc test was not run because the data were binary (either present or absent) and there were no groupings except by sites.



FIGURE 2. Silver Maple Swamp showing pool with hummocks and wet margins. Photo by Garrett E. Crow.

Similarity Index

In addition to the Jaccard's dissimilarity ordination described above, we used the Sørensen Index of Similarity (Mueller-Dombois and Ellenberg 1974) to quantitatively compare the floristic lists of each pair among the four wetland sites. This assessment allowed us to evaluate whether these floristic lists effectively describe the same wetland habitat type, especially with respect to the three shrub-dominated wetlands. The Sørensen Index between two sites is calculated as follows:

$$\text{Sørensen Index} = [2C \div (A+B)] \times 100\%,$$

where C is the number of shared species between the two sites, and A and B are the numbers of species in the first and second site, respectively. An Index value of 50% or more indicates that the two sites are likely the same plant community type (Curtis 1959; Bradley and Crow 2010).

RESULTS AND DISCUSSION

Individual Site Assessments

Silver Maple Swamp (42°53.595'N, 85°21.483'W):

This site (Figure 2) is different from the other three sites in being a forested wetland (1.33 ha or 3.28 acres), best fitting the classification of southern hardwood swamp (Cohen et al. 2015). It is dominated by silver maple (*Acer saccharinum*) along with a lesser presence of red maple (*Acer rubrum*) as well as scattered individuals of American ash (*Fraxinus americana*) and red ash (*F. pennsylvanica*). Virginia creeper (*Parthenocissus quinquefolia*) and poison-ivy (*Toxicodendron radicans*) were in abundance, covering many of the hummocks, while the intermittent pools were well-populated by the sedge, *Carex bromoides* (Figure 3).



FIGURE 3. Silver Maple Swamp showing dominant sedge tussocks of *Carex bromoides* on border of swamp pool. Photo by Garrett E. Crow.

TABLE 2. Species of the Silver Maple Swamp (southern hardwood swamp).

<i>Acer rubrum</i>	<i>Fagus grandifolia</i>	<i>Prunus serotina</i>
<i>Acer saccharinum</i>	<i>Floerkea proserpinacoides</i>	<i>Prunus virginiana</i>
<i>Agrimonia gryposepala</i>	<i>Fraxinus americana</i>	<i>Ranunculus recurvatus</i>
<i>Alliaria petiolata</i>	<i>Fraxinus pennsylvanica</i>	<i>Ribes americanum</i>
<i>Amelanchier laevis</i>	<i>Galium aparine</i>	<i>Ribes cynosbati</i>
<i>Amphicarpaea bracteata</i>	<i>Galium tinctorium</i>	<i>Rosa multiflora</i>
<i>Arisaema triphyllum</i>	<i>Geranium maculatum</i>	<i>Rosa palustris</i>
<i>Bidens connata</i>	<i>Geum canadense</i>	<i>Rubus allegheniensis</i>
<i>Boehmeria cylindrica</i>	<i>Glyceria striata</i>	<i>Rubus occidentalis</i>
<i>Cardamine bulbosa</i>	<i>Impatiens capensis</i>	<i>Rubus pubescens</i>
<i>Carex blanda</i>	<i>Iris virginica</i>	<i>Rubus setosus</i>
<i>Carex bromoides</i>	<i>Leersia virginica</i>	<i>Salix alba</i>
<i>Carex cristatella</i>	<i>Lemna minor</i>	<i>Salix exigua</i>
<i>Carex disperma</i>	<i>Lindera benzoin</i>	<i>Sambucus canadensis</i>
<i>Carex echinata</i>	<i>Liriodendron tulipifera</i>	<i>Sassafras albidum</i>
<i>Carex gracillima</i>	<i>Lycopus americanus</i>	<i>Scirpus atrovirens</i>
<i>Carex interior</i>	<i>Lysimachia thyrsiflora</i>	<i>Scutellaria lateriflora</i>
<i>Carex leptalea</i>	<i>Maianthemum canadense</i>	<i>Sium suave</i>
<i>Carex lupulina</i>	<i>Maianthemum stellatum</i>	<i>Solanum dulcamara</i>
<i>Carex stipata</i>	<i>Mitella diphylla</i>	<i>Solidago caesia</i>
<i>Carpinus caroliniana</i>	<i>Nyssa sylvatica</i>	<i>Symphotrichum lanceolatum</i>
<i>Carya ovata</i>	<i>Onoclea sensibilis</i>	<i>Symplocarpus foetidus</i>
<i>Cephalanthus occidentalis</i>	<i>Osmunda regalis</i>	<i>Taraxacum officinale</i>
<i>Cinna arundinacea</i>	<i>Osmundastrum cinnamomeum</i>	<i>Tilia americana</i>
<i>Circaea canadensis</i>	<i>Parthenocissus quinquefolia</i>	<i>Toxicodendron radicans</i>
<i>Cornus florida</i>	<i>Persicaria virginiana</i>	<i>Urtica dioica</i>
<i>Dioscorea villosa</i>	<i>Phalaris arundinacea</i>	<i>Vaccinium corymbosum</i>
<i>Dryopteris carthusiana</i>	<i>Platanthera clavellata</i>	<i>Viola sororia</i>
<i>Dryopteris intermedia</i>	<i>Poa compressa</i>	<i>Vitis riparia</i>
<i>Elaeagnus umbellata</i>	<i>Podophyllum peltatum</i>	<i>Zanthoxylum americanum</i>
<i>Epilobium coloratum</i>	<i>Prenanthes altissima</i>	
<i>Erythronium americanum</i>	<i>Prunella vulgaris</i>	

A total of 94 species (Table 2), 87 (92.6%) of which are native, were found in this wetland. The Floristic Quality Assessment (Table 1) yielded a Total FQI of 36.8, a Native FQI of 38.2, and a Total Mean C of 3.8. These metrics indicate that this relatively small wetland is floristically important statewide—an important component of Michigan’s native biodiversity. Yet only five species had high C-values of 8-10 (Table 3).

As is typical with this type of swamp, there was an abundance of royal fern (*Osmunda regalis*) and cinnamon fern (*Osmundastrum cinnamomeum*), especially on hummocks and along water edges in the swamp. Southern blue flag (*Iris virginica*), tufted loosestrife (*Lysimachia thyrsiflora*), and skunk-cabbage (*Symplocarpus foetidus*) were also present and locally abundant, as were false nettle (*Boehmeria cylindrica*), wood reedgrass (*Cinna arundinacea*), fowl manna grass (*Glyceria striata*), white grass (*Leersia virginica*), common water horehound (*Lycopus americanus*), reed canary grass (*Phalaris arundinacea*), and water-parsnip (*Sium suave*). Wetland sedges, besides the dominant *Carex bromoides*, included *C. cristatella*, *C. echinata*, *C. gracillima*, *C. interior*, *C. leptalea*, *C. lupulina*, and *C. stipata*. Scattered shrubs of buttonbush (*Cephalan-*

TABLE 3. Species having a C-value of 8–10, indicating a high level of fidelity to a narrow range of undisturbed ecological conditions. An X indicates the presence of a species in that site.

Species	C-value	West Wetland	East Wetland	B. D. White Shrub- Carr	Silver Maple Swamp
<i>Carex disperma</i>	10				X
<i>Carex formosa</i>	10		X		
<i>Carex prairea</i>	10	X	X	X	
<i>Carex prasina</i>	10	X			
<i>Conioselinum chinense</i>	10		X		
<i>Cuscuta campestris</i>	10	X			
<i>Lysimachia quadriflora</i>	10	X			
<i>Micranthes pensylvanica</i>	10	X	X	X	
<i>Muhlenbergia glomerata</i>	10	X			
<i>Pedicularis canadensis</i>	10	X		X	
<i>Valeriana uliginosa</i>	10	X			
<i>Carex tetanica</i>	9	X	X		
<i>Cypripedium reginae</i>	9	X	X	X	
<i>Deschampsia cespitosa</i>	9				
<i>Liriodendron tulipifera</i>	9				X
<i>Nyssa sylvatica</i>	9				X
<i>Poa alsodes</i>	9	X		X	
<i>Rudbeckia fulgida</i>	9	X	X		
<i>Rumex orbiculatus</i>	9	X	X	X	
<i>Salix myricoides</i>	9	X	X	X	
<i>Carex cryptolepis</i>	8	X	X		
<i>Carex lasiocarpa</i>	8	X			
<i>Chimaphila umbellata</i>	8			X	
<i>Cornus florida</i>	8				X
<i>Dasiphora fruticosa</i>	8	X	X	X	
<i>Dryopteris clintoniana</i>	8		X		
<i>Elymus riparius</i>	8	X	X		
<i>Elymus trachycaulus</i>	8	X			
<i>Hypericum ascyron</i>	8	X			
<i>Lysimachia quadrifolia</i>	8	X	X		
<i>Milium effusum</i>	8	X	X		X
<i>Mitella diphylla</i>	8	X			
<i>Pedicularis lanceolata</i>	8	X	X	X	
<i>Quercus bicolor</i>	8			X	
<i>Quercus palustris</i>	8			X	
<i>Rhamnus alnifolia</i>	8	X	X	X	
<i>Salix serissima</i>	8	X		X	
<i>Veronicastrum virginicum</i>	8	X			
<i>Viola nephrophylla</i>	8				
Totals		26	18	14	5

thus occidentalis), spicebush (*Lindera benzoin*), swamp rose (*Rosa palustris*), and sandbar willow (*Salix exigua*) were present as well. Late summer plants included tall white lettuce (*Prenanthes altissima*), bulrush (*Scirpus atrovirens*), bluestem goldenrod (*Solidago caesia*), and paniced aster (*Symphyotrichum lanceolatum*).

Because this swamp lies between two mesic southern forests (Figure 1) (Warners et al. 2021), we encountered a spring flora in May that occurs along



FIGURE 4. East Wetland, southern shrub-carr habitat, with David Warners and Lucas Walker. Photo by Haley R. Weesies.

parts of the outer margin and on some hummocks in the swamp interior, including tall agrimony (*Agrimonia gryposepala*), yellow trout lily (*Erythronium americanum*), false mermaid (*Floerkea proserpinacoides*), wild geranium (*Geranium maculatum*), Canada mayflower (*Maianthemum canadensis*), starry false Solomon-seal (*Maianthemum stellatum*), Bishop's-cap (*Mitella diphylla*), hooked crowfoot (*Ranunculus recurvatus*), and common blue violet (*Viola sororia*).

East Wetland (42°54.055'N, 85°21.180'W):

This open, shrubby wetland (Figure 4) of 1.68 ha (4.15 acres), with its saturated mucky substrate and dominance of dogwoods (*Cornus* spp.) and willows (*Salix* spp.), best fits the Michigan Natural Features Inventory's southern shrub-carr community type (Cohen et al. 2015). A total of 172 species (Table 4), 154

TABLE 4. Comparison of species occurring in the three southern shrub-carr wetlands. Data for the B. D. White Shrub-Carr is from Stockdale et al. 2019 combined with unpublished data from J. Heslinga, Land Conservancy of West Michigan.

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Acer rubrum</i> L. red maple	X	X	X
<i>Achillea millefolium</i> L. yarrow		X	
<i>Actaea rubra</i> (Aiton) Willd. red baneberry	X	X	
<i>Adiantum pedatum</i> L. maidenhair fern	X		
<i>Agrimonia gryposepala</i> Wallr. tall agrimony	X	X	
<i>Agrostis stolonifera</i> L. creeping bent		X	
<i>Alliaria petiolata</i> (M. Bieb.) Cavara & Grande garlic mustard	X		
<i>Amphicarpaea bracteata</i> (L.) Fernald hog peanut	X	X	X
<i>Anemone canadensis</i> L. Canada anemone	X	X	X
<i>Anemone virginiana</i> L. thimbleweed	X		
<i>Angelica atropurpurea</i> L. purplestem angelica	X	X	X
<i>Apios americana</i> Medik. Indian-potato	X	X	X
<i>Apocynum cannabinum</i> L. Indian-hemp	X	X	
<i>Aquilegia canadensis</i> L. wild columbine		X	
<i>Arisaema triphyllum</i> (L.) Schott Jack-in-the-pulpit	X	X	X
<i>Asarum canadense</i> L. wild ginger	X		
<i>Asclepias incarnata</i> L. swamp milkweed	X	X	X
<i>Asclepias syriaca</i> L. common milkweed	X	X	X
<i>Athyrium filix-femina</i> (L.) Roth lady fern	X	X	X
<i>Barbarea vulgaris</i> R. Br. yellow rocket		X	
<i>Berberis thunbergii</i> DC. Japanese barberry			X
<i>Bidens cernua</i> L. nodding beggar-ticks			X
<i>Boehmeria cylindrica</i> (L.) Sw. false nettle		X	X
<i>Bromus ciliatus</i> L. fringed brome	X	X	X
<i>Bromus pubescens</i> Willd. Canada brome	X		

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Calamagrostis canadensis</i> (Michx.) P. Beauv. blue-joint	X	X	X
<i>Caltha palustris</i> L. marsh marigold	X	X	X
<i>Campanula aparinoides</i> Pursh marsh bellflower		X	X
<i>Cardamine bulbosa</i> Muhl.) Britton, Sterns & Poggenb. spring cress	X	X	X
<i>Cardamine concatenata</i> Michx.) O. Schwarz cut-leaved toothwort		X	
<i>Cardamine pensylvanica</i> Willd. Pennsylvania bitter cress			X
<i>Carex annectens</i> (E. P. Bicknell) E. P. Bicknell sedge		X	
<i>Carex aquatilis</i> Wahlenb. sedge			X
<i>Carex bebbii</i> (L. H. Bailey) Fernald sedge		X	X
<i>Carex blanda</i> Dewey sedge		X	
<i>Carex bromoides</i> Willd. sedge	X	X	X
<i>Carex cephalophora</i> Willd. sedge			X
<i>Carex comosa</i> Boott sedge	X		
<i>Carex crinita</i> Lam. sedge	X	X	X
<i>Carex cristatella</i> Britton sedge		X	X
<i>Carex cryptolepis</i> Mack. sedge	X	X	
<i>Carex davisii</i> Schwein. & Torr. Special Concern Davis' sedge	X		
<i>Carex gracillima</i> Schwein. sedge	X	X	X
<i>Carex grayi</i> J. Carey sedge	X	X	
<i>Carex grisea</i> Wahlenb. sedge	X	X	
<i>Carex hirtifolia</i> Mack. sedge	X	X	
<i>Carex hystericina</i> Willd. sedge	X	X	X
<i>Carex interior</i> L. H. Bailey sedge	X	X	
<i>Carex lacustris</i> Willd. sedge	X	X	X
<i>Carex leptalea</i> Wahlenb. sedge	X	X	X
<i>Carex lupulina</i> Willd. sedge	X		

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Carex lurida</i> Wahlenb. sedge		X	
<i>Carex normalis</i> Mack. sedge	X		
<i>Carex pellita</i> Willd. sedge	X	X	X
<i>Carex prairea</i> Dewey sedge	X	X	X
<i>Carex prasina</i> Wahlenb. sedge		X	
<i>Carex stipata</i> Willd. sedge	X	X	X
<i>Carex stricta</i> Lam. sedge	X	X	X
<i>Carex tetanica</i> Schkuhr sedge	X	X	
<i>Carex vulpinoidea</i> Michx. sedge	X		X
<i>Carpinus caroliniana</i> Walter blue-beech	X	X	
<i>Celastrus orbiculatus</i> Thunb. oriental bittersweet	X		
<i>Chelone glabra</i> L. turtlehead		X	X
<i>Chimaphila umbellata</i> (L.) Nutt. pipsissewa			X
<i>Cicuta bulbifera</i> L. water hemlock	X		X
<i>Cicuta maculata</i> L. water hemlock	X	X	X
<i>Cinna arundinacea</i> L. wood reedgrass		X	X
<i>Circaea canadensis</i> (L.) Hill enchanter's nightshade	X	X	X
<i>Cirsium muticum</i> Michx. swamp thistle	X	X	X
<i>Claytonia virginica</i> L. spring beauty		X	X
<i>Clematis virginiana</i> L. virgin's bower	X	X	X
<i>Conioselinum chinense</i> (L.) Britton, Sterns & Poggenb. hemlock-parsley	X		
<i>Conium maculatum</i> L. poison hemlock	X		
<i>Cornus amomum</i> Mill. silky dogwood	X	X	X
<i>Cornus foemina</i> Mill. gray dogwood	X	X	X
<i>Cornus sericea</i> L. red-osier	X	X	X
<i>Corylus americana</i> Walter hazelnut	X	X	X

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Cryptotaenia canadensis</i> (L.) DC. honewort	X	X	X
<i>Cuscuta campestris</i> Yuncker Special Concern field dodder		X	
<i>Cuscuta gronovii</i> Roem. & Schult. common dodder			X
<i>Cypripedium reginae</i> Walter showy lady slipper	X	X	
<i>Dactylis glomerata</i> L. orchard grass		X	
<i>Dasiphora fruticosa</i> (L.) Rydb. shrubby cinquefoil	X	X	X
<i>Dichanthelium clandestinum</i> L.) Gould panic grass	X		
<i>Deschampsia cespitosa</i> (L.) P. Beauv. hair grass			X
<i>Desmodium canadense</i> (L.) DC. showy tick-trefoil		X	
<i>Diervilla lonicera</i> Mill. bush honeysuckle		X	
<i>Dioscorea villosa</i> L. wild yam	X	X	X
<i>Doellingeria umbellata</i> (Mill.) Nees flat-topped white aster	X	X	
<i>Dryopteris clintoniana</i> (D. C. Eaton) Dowell Clinton's woodfern	X		
<i>Dryopteris cristata</i> (L.) A. Gray crested shield fern	X	X	X
<i>Dryopteris intermedia</i> (Willd.) A. Gray evergreen woodfern	X		
<i>Elaeagnus umbellata</i> Thunb. autumn olive	X	X	
<i>Eleocharis erythropoda</i> Steud. spike-rush		X	X
<i>Eleocharis intermedia</i> Schult. spike-rush			X
<i>Elymus canadensis</i> L. Canada wild rye	X		
<i>Elymus hystrix</i> L. bottlebrush grass	X	X	X
<i>Elymus repens</i> (L.) Gould quack grass	X		
<i>Elymus riparius</i> Wiegand riverbank wild rye	X	X	
<i>Elymus trachycaulus</i> (Link) Gould slender wheatgrass		X	
<i>Elymus villosus</i> Willd. silky wild rye	X	X	
<i>Elymus virginicus</i> L. Virginia wild rye		X	X
<i>Epilobium ciliatum</i> Raf. willow herb		X	

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Epilobium coloratum</i> Biehler cinnamon willow herb			X
<i>Epilobium parviflorum</i> Schreb. willow herb		X	X
<i>Epilobium hirsutum</i> L. great hairy willow herb	X		
<i>Epipactis helleborine</i> (L.) Crantz helleborine	X		
<i>Equisetum arvense</i> L. common horsetail	X	X	X
<i>Erigeron annuus</i> (L.) Pers. daisy fleabane		X	X
<i>Erigeron philadelphicus</i> L. Philadelphia fleabane		X	
<i>Euonymus obovatus</i> Nutt. running strawberry bush		X	
<i>Eupatorium perfoliatum</i> L. boneset	X	X	X
<i>Eutrochium maculatum</i> (L.) E. E. Lamont joe-pye weed	X	X	X
<i>Festuca subverticillata</i> (Pers.) E. B. Alexeev nodding fescue		X	
<i>Fragaria virginiana</i> Mill. wild strawberry		X	
<i>Frangula alnus</i> Mill. glossy buckthorn	X		X
<i>Fraxinus nigra</i> Marshall black ash		X	
<i>Fraxinus pennsylvanica</i> Marshall green ash		X	X
<i>Galium aparine</i> L. annual bedstraw	X	X	X
<i>Galium asprellum</i> Michx. rough bedstraw		X	X
<i>Galium boreale</i> L. northern bedstraw	X	X	
<i>Galium obtusum</i> Bigelow wild madder		X	
<i>Galium tinctorium</i> L. stiff bedstraw			X
<i>Gaylussacia baccata</i> (Wangenh.) K. Koch huckleberry			X
<i>Geranium maculatum</i> L. wild geranium	X	X	X
<i>Geum aleppicum</i> Jacq. yellow avens		X	X
<i>Geum canadense</i> Jacq. white avens	X		
<i>Geum rivale</i> L. purple avens	X	X	X
<i>Glyceria grandis</i> S. Watson reed manna grass		X	X

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Glyceria striata</i> (Lam.) Hitchc. fowl manna grass	X	X	X
<i>Hackelia virginiana</i> (L.) I. M. Johnst. beggar's lice			X
<i>Hamamelis virginiana</i> L. witch-hazel			X
<i>Helianthus decapetalus</i> L. pale sunflower		X	
<i>Helianthus giganteus</i> L. tall sunflower	X	X	
<i>Hypericum ascyron</i> L. giant St. John's-wort		X	
<i>Hypericum boreale</i> (Britt.) E. P. Bicknell northern St. John's-wort			X
<i>Hypericum prolificum</i> L. shrubby St. John's-wort		X	
<i>Hypericum punctatum</i> Lam. spotted St. John's-wort	X	X	X
<i>Ilex verticillata</i> (L.) A. Gray Michigan holly	X	X	X
<i>Impatiens capensis</i> Meerb. spotted touch-me-not	X	X	X
<i>Iris virginica</i> L. southern blue flag	X	X	X
<i>Juglans cinerea</i> L. butternut	X		
<i>Juglans nigra</i> L. black walnut			X
<i>Juncus dudleyi</i> Wiegand Dudley's rush	X	X	
<i>Juncus nodosus</i> L. joint rush		X	
<i>Juncus pylaei</i> Laharpe Pylaie's soft rush		X	
<i>Juncus tenuis</i> Willd. path rush			X
<i>Juniperus virginiana</i> L. red cedar		X	
<i>Laportea canadensis</i> (L.) Wedd. wood nettle	X	X	
<i>Lathyrus palustris</i> L. marsh pea	X	X	X
<i>Leersia oryzoides</i> (L.) Sw. white grass			X
<i>Lemna minor</i> L. common duckweed	X	X	X
<i>Lemna turionifera</i> Landolt red duckweed		X	
<i>Leonurus cardiaca</i> L. motherwort	X		
<i>Lilium michiganense</i> Farw. Michigan lily	X	X	

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Liparis loeselii</i> (L.) Rich. green twayblade, fen orchid		X	
<i>Lindera benzoin</i> (L.) Blume spicebush	X	X	
<i>Lobelia siphilitica</i> L. great blue lobelia	X	X	
<i>Lonicera dioica</i> L. glaucous honeysuckle		X	
<i>Lonicera maackii</i> (Rupr.) Herder amur honeysuckle			X
<i>Lonicera morrowii</i> A. Gray morrow honeysuckle			X
<i>Luzula multiflora</i> (Ehrh.) Lej. common wood rush		X	
<i>Ludwigia palustris</i> (L.) Elliott water-purslane	X		
<i>Lycopus americanus</i> Muhl. common water horehound	X	X	X
<i>Lysimachia ciliata</i> L. fringed loosestrife	X	X	X
<i>Lysimachia quadriflora</i> Sims four-flowered loosestrife		X	
<i>Lysimachia quadrifolia</i> L. whorled loosestrife		X	
<i>Lysimachia thyrsiflora</i> L. tufted loosestrife		X	X
<i>Maianthemum racemosum</i> (L.) Link false spikenard			X
<i>Maianthemum stellatum</i> (L.) Link starry false Solomon-seal	X	X	
<i>Matteuccia struthiopteris</i> (L.) Todaro ostrich fern		X	
<i>Menispermum canadense</i> L. moonseed			X
<i>Mentha canadensis</i> L. wild mint	X	X	
<i>Micranthes pennsylvanica</i> (L.) Haw. swamp saxifrage	X	X	X
<i>Milium effusum</i> L. wood millet	X	X	
<i>Mitella diphylla</i> L. bishop's cap		X	
<i>Monarda fistulosa</i> L. wild bergamot	X	X	X
<i>Muhlenbergia glomerata</i> (Willd.) Trin. marsh wild timothy		X	
<i>Muhlenbergia mexicana</i> (L.) Trin. leafy satin grass		X	
<i>Nasturtium microphyllum</i> Rchb. watercress	X	X	X
<i>Onoclea sensibilis</i> L. sensitive fern	X	X	X

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Osmorhiza longistylis</i> (Torr.) DC. smooth sweet cicely		X	
<i>Osmundastrum cinnamomeum</i> (L.) C. Presl cinnamon fern	X	X	X
<i>Osmunda claytoniana</i> L. interrupted fern		X	
<i>Osmunda regalis</i> L. royal fern		X	X
<i>Oxalis stricta</i> L. yellow wood-sorrel			X
<i>Oxypolis rigidior</i> (L.) Raf. cowbane	X	X	
<i>Packera aurea</i> (L.) Á. Löve & D. Löve golden ragwort	X	X	X
<i>Parthenocissus quinquefolia</i> (L.) Planch. Virginia creeper			X
<i>Pedicularis canadensis</i> L. wood betony		X	X
<i>Pedicularis lanceolata</i> Michx. swamp betony	X	X	X
<i>Persicaria amphibia</i> (L.) Delabare water smartweed			X
<i>Persicaria hydropiper</i> (L.) Delabare water-pepper			X
<i>Persicaria pensylvanica</i> (L.) M. Gómez pinkweed		X	X
<i>Persicaria punctata</i> (Elliott) Small smartweed		X	X
<i>Persicaria sagittata</i> (L.) H. Gross arrow-leaved tear-thumb	X	X	X
<i>Persicaria virginiana</i> (L.) Gaertn. jumpseed	X	X	X
<i>Phalaris arundinacea</i> L. reed canary grass	X	X	X
<i>Phlox divaricata</i> L. wild blue phlox		X	
<i>Physocarpus opulifolius</i> (L.) Maxim. ninebark	X	X	X
<i>Pilea pumila</i> (L.) A. Gray clearweed			X
<i>Platanthera psycodes</i> (L.) Lindl. purple fringed orchid	X	X	X
<i>Poa alsodes</i> A. Gray bluegrass		X	X
<i>Poa compressa</i> L. Canada bluegrass		X	
<i>Poa palustris</i> L. fowl meadow grass	X	X	X
<i>Poa pratensis</i> L. Kentucky bluegrass	X	X	
<i>Poa trivialis</i> L. bluegrass	X	X	

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Podophyllum peltatum</i> L. May-apple	X	X	
<i>Polygonatum biflorum</i> (Walter) Elliott Solomon-seal	X		
<i>Polygonatum pubescens</i> (Willd.) Pursh downy Solomon-seal		X	
<i>Populus deltoides</i> Marshall cottonwood	X		X
<i>Populus tremuloides</i> Michx. quaking aspen	X	X	X
<i>Potentilla simplex</i> Michx. common cinquefoil		X	
<i>Prenanthes alba</i> L. white lettuce	X		
<i>Prunella vulgaris</i> L. self-heal	X	X	X
<i>Prunus serotina</i> Ehrh. wild black cherry			X
<i>Prunus virginiana</i> L. choke cherry		X	
<i>Pycnanthemum virginianum</i> (L.) Durand & Jackson common mountain mint	X	X	X
<i>Pyrola elliptica</i> Nutt. large-leaved shinleaf		X	
<i>Quercus bicolor</i> Willd. swamp white oak			X
<i>Quercus macrocarpa</i> Michx. bur oak	X	X	X
<i>Quercus palustris</i> Munchh. pin oak			X
<i>Quercus velutina</i> Lam. black oak		X	
<i>Ranunculus abortivus</i> L. small-flowered buttercup			X
<i>Ranunculus hispidus</i> Michx. swamp buttercup	X	X	X
<i>Ranunculus recurvatus</i> Poir. hooked crowfoot	X	X	X
<i>Ranunculus sceleratus</i> L. cursed crowfoot		X	
<i>Rhamnus alnifolia</i> L'Her. alder-leaved buckthorn	X	X	X
<i>Rhus glabra</i> L. smooth sumac		X	X
<i>Ribes americanum</i> Mill. wild black currant	X	X	X
<i>Ribes cynosbati</i> L. prickly gooseberry		X	X
<i>Ribes hirtellum</i> Michx. swamp gooseberry		X	X
<i>Rosa multiflora</i> Murray multiflora rose	X	X	X

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Rosa palustris</i> Marshall swamp rose	X	X	X
<i>Rubus allegheniensis</i> Porter common blackberry		X	
<i>Rubus hispidus</i> L. swamp dewberry		X	X
<i>Rubus occidentalis</i> L. black raspberry	X	X	X
<i>Rubus pubescens</i> Raf. dwarf raspberry	X	X	X
<i>Rubus strigosus</i> Michx. wild red raspberry			X
<i>Rudbeckia fulgida</i> Aiton showy coneflower	X	X	
<i>Rudbeckia hirta</i> L. black-eyed Susan	X	X	
<i>Rudbeckia laciniata</i> L. cut-leaf coneflower	X	X	X
<i>Rumex crispus</i> L. curly dock		X	X
<i>Rumex obtusifolius</i> L. bitter dock	X	X	X
<i>Rumex orbiculatus</i> A. Gray great water dock	X	X	
<i>Sagittaria latifolia</i> Willd. common arrowhead			X
<i>Salix bebbiana</i> Sarg. beaked willow		X	X
<i>Salix discolor</i> Muhl. pussy willow		X	
<i>Salix eriocephala</i> Michx. willow	X	X	X
<i>Salix exigua</i> Nutt. sandbar willow		X	X
<i>Salix lucida</i> Muhl. shining willow			X
<i>Salix myricoides</i> Muhl. blueleaf willow	X	X	X
<i>Salix nigra</i> Marshall black willow		X	
<i>Salix petiolaris</i> Sm. slender willow	X	X	X
<i>Salix sericea</i> Marshall silky willow			X
<i>Salix serissima</i> (L. H. Bailey) Fernald autumn willow		X	X
<i>Sambucus canadensis</i> L. elderberry	X	X	X
<i>Sanicula odorata</i> (Raf.) Pryer & Phillippe black snakeroot	X	X	
<i>Saponaria officinalis</i> L. soapwort		X	

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Schoenoplectus tabernaemontani</i> (C. C. Gmel.) Palla softstem bulrush	X	X	X
<i>Scirpus atrovirens</i> Willd. bulrush	X	X	X
<i>Scirpus cyperinus</i> (L.) Kunth wool-grass		X	X
<i>Scirpus expansus</i> Fernald bulrush			X
<i>Scirpus pendulus</i> Muhl. bulrush		X	
<i>Scrophularia marilandica</i> L. late figwort			X
<i>Scutellaria galericulata</i> L. marsh skullcap			X
<i>Scutellaria lateriflora</i> L. mad-dog skullcap			X
<i>Sium suave</i> Walter water parsnip			X
<i>Smilax hispida</i> Raf. bristly greenbrier	X		X
<i>Solanum dulcamara</i> L. bittersweet nightshade	X	X	X
<i>Solidago altissima</i> L. tall goldenrod		X	
<i>Solidago canadensis</i> L. Canada goldenrod		X	
<i>Solidago gigantea</i> Aiton late goldenrod		X	X
<i>Solidago patula</i> Muhl. swamp goldenrod	X	X	X
<i>Solidago riddellii</i> Frank Riddell's goldenrod		X	
<i>Solidago rugosa</i> Mill. rough-leaved goldenrod	X	X	X
<i>Solidago uliginosa</i> Nutt. bog goldenrod		X	
<i>Sphenopholis intermedia</i> (Rydb.) Rydb. slender wedgegrass	X		X
<i>Spiraea alba</i> Du Roi meadowsweet	X	X	X
<i>Stellaria longifolia</i> Willd. long-leaved chickweed	X	X	X
<i>Symphyotrichum firmum</i> (Nees) G. L. Nesom smooth swamp aster	X	X	X
<i>Symphyotrichum laeve</i> (L.) G. L. Nesom smooth aster		X	
<i>Symphyotrichum lanceolatum</i> (Willd.) G. L. Nesom panicked aster	X		
<i>Symphyotrichum lateriflorum</i> (L.) Á. Löve & D. Löve calico aster		X	X
<i>Symphyotrichum ontarionis</i> (Wiegand) G. L. Nesom Lake Ontario aster			X

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Symphotrichum pilosum</i> (Willd.) G. L. Nesom frost aster		X	
<i>Symphotrichum puniceum</i> (L.) Á. Löve & D. Löve purple-stemmed aster	X	X	X
<i>Symplocarpus foetidus</i> (L.) Nutt. skunk-cabbage	X	X	X
<i>Taraxacum officinale</i> F. H. Wigg. common dandelion		X	X
<i>Thalictrum dasycarpum</i> Fisch. & Avé-Lall. purple meadow-rue	X	X	X
<i>Thelypteris noveboracensis</i> (L.) Nieuwl. New York fern	X		X
<i>Thelypteris palustris</i> Schott marsh fern	X	X	X
<i>Tilia americana</i> L. basswood	X	X	
<i>Torilis japonica</i> (Houtt.) DC. hedge parsley		X	
<i>Toxicodendron radicans</i> (L.) Kuntze poison ivy	X	X	X
<i>Toxicodendron vernix</i> (L.) Kuntze poison sumac	X	X	X
<i>Trillium grandiflorum</i> (Michx.) Salisb. common trillium	X	X	
<i>Typha angustifolia</i> L. narrow-leaved cattail	X		
<i>Typha latifolia</i> L. broad-leaved cattail			X
<i>Ulmus americana</i> L. American elm		X	X
<i>Ulmus rubra</i> Muhl. red elm		X	
<i>Urtica dioica</i> L. stinging nettle	X	X	X
<i>Vaccinium corymbosum</i> L. highbush blueberry			X
<i>Vaccinium myrtilloides</i> Michx. velvetleaf blueberry			X
<i>Valeriana officinalis</i> L. common valerian	X		
<i>Valeriana uliginosa</i> (Torr. & A. Gray) Rydb. swamp valerian		X	
<i>Verbena hastata</i> L. blue vervain		X	X
<i>Veronicastrum virginicum</i> (L.) Farw. Culver's root		X	
<i>Viburnum cassinoides</i> L. wild raisin			X
<i>Viburnum lentago</i> L. nannyberry	X	X	X
<i>Viburnum opulus</i> L. European highbush cranberry	X		X

(Continued on next page)

TABLE 4. (Continued).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
<i>Viburnum rafinesquianum</i> Schult. downy arrowhead		X	X
<i>Vincetoxicum nigrum</i> (L.) Pers. black swallow-wort		X	
<i>Viola cucullata</i> Aiton marsh violet	X	X	X
<i>Viola labradorica</i> Schrank dog violet			X
<i>Viola macloskeyi</i> F. E. Lloyd smooth white violet			X
<i>Viola sororia</i> Willd. common blue violet		X	
<i>Viola striata</i> Aiton cream violet		X	
<i>Vitis riparia</i> Michx. riverbank grape	X	X	X
<i>Zanthoxylum americanum</i> Mill. prickly ash		X	X
<i>Zizia aurea</i> (L.) W. D. J. Koch golden Alexanders	X	X	X
Total species	172	238	192
Native species	154 (89.5%)	221 (92.9%)	180 (93.8%)
Non-native species	18 (10.5%)	17 (7.1%)	12 (6.3%)

(89.5%) of which are native, were found in this wetland. The Floristic Quality Assessment metrics of this site (Table 1) are quite high: a Total FQI of 52.5, a Native FQI of 55.8, and a Total Mean C of 4.4.

Common shrub species in the East Wetland shrub-carr are: dogwoods (*Cornus sericea*, *C. foemina*, *C. amomum*), buckthorns (*Frangula alnus*, *Rhamnus alnifolia*), willows (*Salix eriocephala*, *S. myricoides*, *S. petiolaris*, *S. bebbiana*), poison sumac (*Toxicodendron vernix*), and viburnums (*Viburnum lentago*, *V. opulus*). The presence of occasional calciphiles suggests a fen-like quality in certain zones. These include prairie sedge (*Carex prairea*), tussock sedge (*Carex stricta*), another smaller sedge (*Carex tetanica*), shrubby cinquefoil (*Dasiphora fruticosa*), swamp saxifrage (*Micranthes pensylvanica*), swamp-betony (*Pedicularis lanceolata*), Virginia mountain mint (*Pycnanthemum virginianum*), black-eyed Susan (*Rudbeckia fulgida*), blueleaf willow (*Salix myricoides*), and swamp valerian (*Valeriana uliginosa*). Additional common herbaceous species include bluejoint grass (*Calamagrostis canadensis*), flat-topped white aster (*Doellingeria umbellata*), Clinton’s woodfern (*Dryopteris clintoniana*), common boneset (*Eupatorium perfoliatum*), joe-pye-weed (*Eutrochium maculatum*), including an albino form, golden ragwort (*Packera aurea*), smooth swamp aster (*Symphotrichum firmum*), side-flowering aster (*S. lateriflorum*), swamp aster (*S. puniceum*), and marsh fern (*Thelypteris palustris*). The genus *Carex* is well rep-

resented with 21 species in this small wetland. Three viny species, hog-peanut (*Amphicarpaea bracteata*), groundnut (*Apios americana*), and wild yam (*Dioscorea villosa*) are also common.

One state-listed species, Davis' sedge (*Carex davisii*) (Special Concern status) was encountered in this wetland. Additionally, two orchids of interest were discovered: the showy lady-slipper (*Cypripedium reginae*) and purple fringed orchid (*Platanthera psycodes*). A total of 18 species from this site have high C-values (Table 3).

West Wetland (42°53.976'N, 85°21.583'W):

The West Wetland (Figure 5) is the largest of the four wetlands surveyed in this study, at 3.71 ha (9.18 acres). This wetland is also best classified as a southern shrub-carr community (Cohen et al. 2015). A total of 238 species (Table 4), 221 (92.9%) of which are native, were found in this wetland (Table 1). The Floristic Quality Assessment metrics of this site (Table 1) are remarkably high: a Total FQI of 63.3, a Native FQI of 65.4, and a Total Mean C of 4.1. This wetland is clearly an important refuge for native biodiversity and has significant conservation value at a statewide level, extremely worthy of protection and conservation by Kent County Parks.

The border of this wetland is shaded by nearby trees and dense shrubs. The substrate is mucky, difficult to traverse, and dominated by skunk-cabbage (*Symplocarpus foetidus*) and sensitive fern (*Onoclea sensibilis*). Towards the interior, shrubby growth occurs in patches, interrupted by an open mosaic of microhabitats populated by herbaceous species typical of southern sedge meadows or fens. Some of the most common shrubs are hazelnut (*Corylus americana*), dogwoods (*Cornus amomum*, *C. foemina*, and *C. sericea*), willows (*Salix bebbiana*, *S. myricoides*, and *S. serissima*), poison sumac (*Toxicodendron vernix*), and viburnums (*Viburnum lentago* and *V. rafinesquianum*). The open areas are marked by several calciphiles, including prairie sedge (*Carex prairea*), another smaller sedge (*Carex tetanica*), shrubby cinquefoil (*Dasiphora fruticosa*), marsh wild timothy (*Muhlenbergia glomerata*), alder-leaved buckthorn (*Rhamnus alnifolia*), black-eyed Susan (*Rudbeckia fulgida*), blueleaf willow (*Salix myricoides*), swamp valerian (*Valeriana uliginosa*), and golden Alexanders (*Zizia aurea*). *Carex stricta* is the dominant species in other open zones, where it is joined by swamp milkweed (*Asclepias incarnata*), golden ragwort (*Packera aurea*), green bulrush (*Scirpus atrovirens*), and other less dominant graminoids (*Bromus ciliatus*, *Calamagrostis canadensis*, *Carex interior*, *C. pellita*, *C. stipata*, and *Glyceria striata*). One tall forb, giant St. John's-wort (*Hypericum ascyron*), is well-represented in one of the *Carex stricta* areas, and our documentation of this species is the first for Kent County since Emma Cole collected it in 1893 (MICHIGAN FLORA ONLINE 2011). Isolated clones of quaking aspen trees (*Populus tremuloides*) are scattered throughout this wetland.

One species in the West Wetland shrub-carr is listed in Michigan as Special Concern—the parasitic field dodder (*Cuscuta campestris*); this species also constitutes a new county record (it was previously known from only five other counties in Michigan). Additionally, three fairly rare orchids were encountered:



FIGURE 5. West Wetland, southern shrub-carr habitat. Photo by DeAnna Clum.

showy lady slipper (*Cypripedium reginae*); purple fringed orchid (*Platanthera psycodes*); and the fen orchid or green twayblade (*Liparis loeselii*), which had previously been documented in Kent County only in 1940, 1946, and 1969 (MICHIGAN FLORA ONLINE 2011).

Only 7.2% of the flora in this wetland consists of non-native species, a few of which are considered aggressive. While they have not yet become problematic, these non-natives include autumn olive (*Elaeagnus umbellata*), Canada and Kentucky bluegrass (*Poa compressa*, *P. pratensis*), multiflora rose (*Rosa multiflora*), and curly and bitter dock (*Rumex crispus*, *R. obtusifolius*). The inventory of this southern shrub-carr wetland included a large number of species (26) with *C*-values ranging from 8 to 10, indicating a high concentration of species with preference for undisturbed habitats (Table 3).

B. D. White Shrub-Carr (42° 54.313'N, 85°21.631'W):

This wetland (Figure 6) is similar in size to the upstream shrub-carr wetlands (3.48 ha or 8.6 acres) and in the same drainage system. Karen Creek flows into this shrub-carr, dissipates across its broad basin, then collects again and ultimately winds its way to the north, emptying into the Grand River at Grand River Riverfront Park in the city of Lowell. For this assessment we combined inventory data from a previous report on the B. D. White Shrub-Carr (Stockdale et al. 2019) with unpublished data provided by J. Heslinga (Stewardship Director,



FIGURE 6. B. D. White Shrub-Carr, southern shrub-carr habitat, with tall *Angelica atropurpurea*. Photo by Garrett E. Crow.

Land Conservancy of West Michigan). This combined dataset resulted in 192 species (Table 4), 180 (93.8%) of which are native. The Floristic Quality Assessment calculations (Table 1) yielded a Total FQI of 55.4, a Native FQI of 56.3, and a Total Mean *C* of 4.0. These results are slightly lower than those of the West Wetland, but marginally higher than those of East Wetland.

Prairie Pond/Marsh (42°53.678'N, 85°21.348'W):

One additional wetland occurs within the Lowell Regional Greenspace, the Prairie Pond/Marsh site (Figure 1: PM). This site is an old farm pond of ca. 0.68 ha (1.67 acres) that lies within an open old-field portion of the Greenspace that Kent County Parks has begun managing as a 30-acre prairie restoration. Prior to agricultural development, this wetland likely supported a southern hardwood swamp similar to the Silver Maple Swamp site. Since the site represents a for-

mer farm pond and shows a high degree of disturbance, we did not conduct a full botanical inventory, nor did we include this site in our comparisons. However, we offer a brief description here for the benefit of Kent County Parks.

Today this wetland is an open marsh surrounding the pond with a few young and widely scattered trees of silver maple (*Acer saccharinum*), American ash (*Fraxinus americana*), willow (*Salix* cf. *alba*), and American elm (*Ulmus americana*). The margins and shallow zones are populated with reed canary grass (*Phalaris arundinacea*), sandbar willow (*Salix exigua*), softstem bulrush (*Schoenoplectus tabernaemontani*), bulrush (*Scirpus atrovirens*) and Canada goldenrod (*Solidago canadensis*). Also present are scattered individuals of northern water-plantain (*Alisma triviale*), swamp milkweed (*Asclepias incarnata*), false nettle (*Boehmeria cylindrica*), the sedges *Carex crinita*, *C. tribuloides*, *C. vulpinoidea*, willow-herb (*Epilobium ciliatum*), spotted touch-me-not (*Impatiens capensis*), Pylaei's soft rush (*Juncus pylaei*), common water horehound (*Lycopus americanus*), multiflora rose (*Rosa multiflora*), curly dock (*Rumex crispus*), mad-dog skullcap (*Scutellaria lateriflora*), stinging nettle (*Urtica dioica*), and white vervain (*Verbena urticifolia*).

Non-metric Multidimensional Ordination (NMDS)

The NMDS ordination (Figure 7) shows that the tree-dominated Silver Maple Swamp is distantly set apart from the three shrub-carrs, indicating that it is clearly the most dissimilar among the four wetlands. The East Wetland and the West Wetland cluster close together and are positioned relatively close to the B. D. White Shrub-Carr. However, the cluster is not sufficiently tight to permit the conclusion from this analysis alone that they are necessarily the same community type.

Similarity Index

The Sørensen Index of Similarity defines two sites as the same plant community type when they exhibit a Similarity Index greater than 50% (Curtis 1959; Bradley and Crow 2010). Figure 8 reports pairwise comparisons of all four wetlands. East Wetland and West Wetland, with a Sørensen Index score of 66.34%, showed the strongest affinity. This assessment also reports a range in Index scores of 59.89–66.34% (109–138 shared species) for all three pairwise comparisons of the shrub-carrs, thereby giving us confidence to conclude that these three wetlands belong to the same community type—southern shrub-carr. The Silver Maple Swamp differed considerably from the three shrub-carrs with a Sørensen Index ranging from 35.05 to 35.79% for all pairwise comparisons. Additionally, species richness was much lower in the swamp (94 species) than in the shrub carrs, and the number of species shared between the swamp and shrub carr sites was also low, ranging from 47 to 51. These results affirmed our impression that this is a very different habitat and that it belongs to a different community type, in this case a southern hardwood swamp (Cohen et al. 2015).

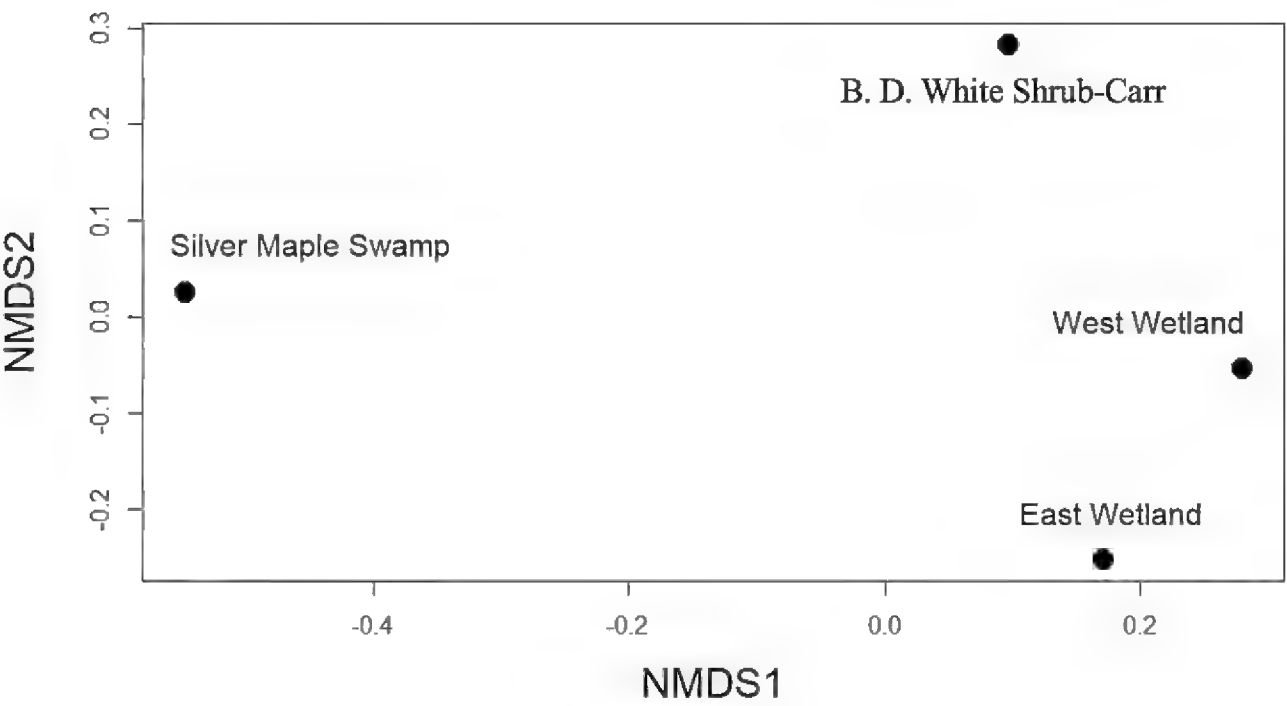


FIGURE 7. NMDS ordination demonstrating the relative similarity of the four wetland sites using a Jaccard distance metric. Points are labeled with the name of each site. Stress = 0.

CONCLUSION

As a consequence of agricultural and urban development, logging, and hydrological alterations, large sectors of the Michigan landscape have been significantly degraded from their pre-settlement condition. One outcome of these intense human activities is that much of Michigan’s native biota has become severely restricted to small, isolated tracts of natural landscapes, which have themselves been impacted by surrounding growth and development (Zipperer 1993; Hartley and Hunter 1998). According to Herman et al. (2001), many of the principal floristic elements of our natural ecosystems are poorly represented in Michigan’s present human-dominated landscape.

This paper is part of an ongoing botanical inventory project of the greater Grand Rapids area in which we have been assessing sites that Emma Cole described in her *Flora of Grand Rapids* (Cole 1901; Crow 2017) over 120 years ago, along with other high-quality remnant natural areas in the region. As a teacher of botany at Central High School, and as the curator of the herbarium of the Kent Scientific Institute, Cole saw the need for an up-to-date account of the plants of the area to involve her students in the study of systematic botany. She engaged in intensive botanical collecting during the years 1892 to 1899 by horse and buggy, and, with the help and encouragement of various high school students of botany, former teachers, and some local botanical enthusiasts, she was able to compile a thorough record of the plant species growing without cultivation within 16 townships, comprising 585 square miles, centered on Grand Rapids (Stivers and Crow 2018).

Enormous changes have taken place within and around the Grand Rapids area that have impacted the botanical richness of the region, both as a direct consequence of urbanization and as a result of expanded agricultural and suburban de-

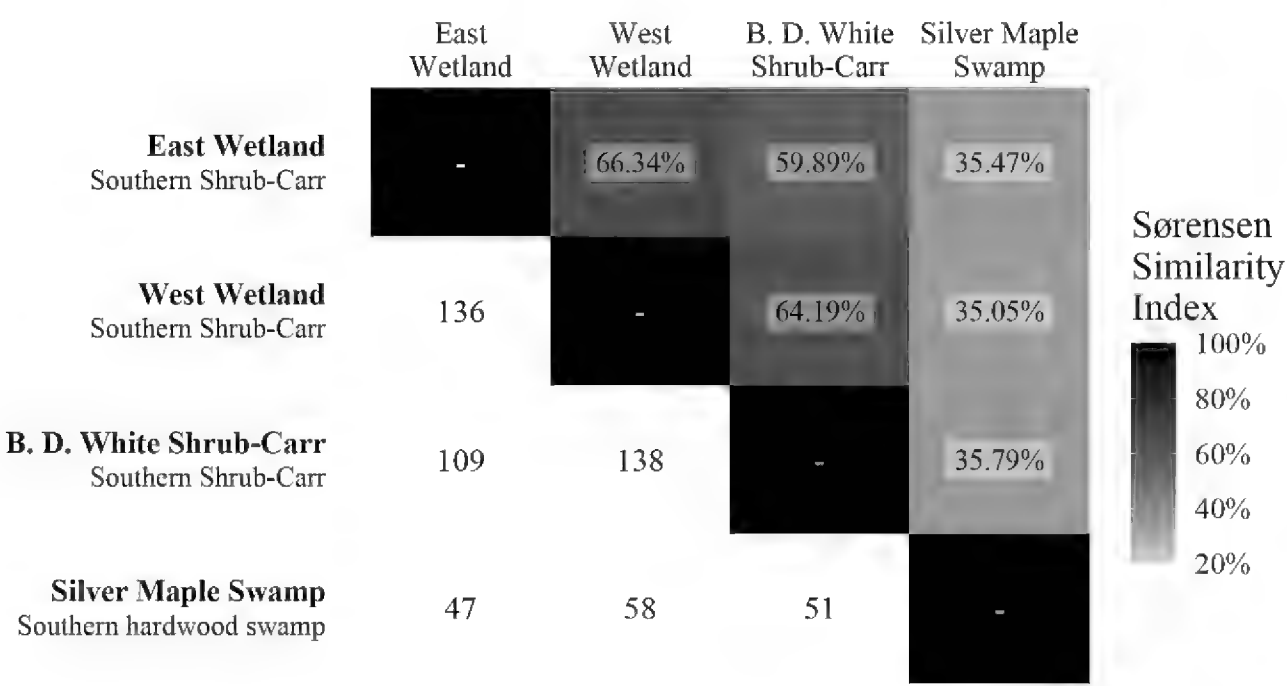


FIGURE 8. Sørensen Index of Similarity pairwise comparisons for the four wetland sites. Values in the shaded boxes to the upper right of the diagonal are the percentage similarity of each pair; values to the lower left of the diagonal are the number of species shared between pairs of wetland sites. The community classification of each site is indicated in the left column under the name of that site.

velopment. While it has been disheartening to discover the loss of many of Cole’s collecting sites, we have also been encouraged to find some of her sites as well as other natural remnants that still retain high levels of ecological integrity and biodiversity.

In this paper, which is a companion study to an earlier assessment of the woodlands on this Kent County Parks property (see Warners et al. 2021), we inventoried and compared three natural wetlands within the Lowell Regional Greenspace together with a fourth wetland just downstream in the Karen Creek drainage. While the southern hardwood swamp was quite distinct from the three shrub-carrs, both in physiognomy and in floristic similarity (Figures 7 and 8), the shrub-carrs themselves exhibit a remarkable degree of similarity in Floristic Quality Assessment values (Table 1). Their Total FQIs of 52.5 (EW), 55.4 (BDW) and 63.3 (WW) all indicate unusually high natural quality, worthy of protection and long-term preservation by Kent County Parks. While the southern hardwood swamp detailed in this study appeared largely undisturbed and of high natural quality, it supported a far lower species richness than any of the shrub-carr sites. The lower species richness and FQI in swamps, compared to shrub-carrs, is likely related to less environmental variation (light in particular). By contrast, shrub-carrs host a diversity of microhabitats, due to their undulating topography and variable light levels, and therefore can support higher species richness. In fact, this research shows that even relatively small shrub-carrs (all < 4 ha in size) can serve as refuges for significant amounts of native biodiversity.

This study also underscores the importance of vigilantly monitoring and managing shrub-carr communities. Monitoring and removal of non-native invasive species will enhance the rich native character of these sites. In the shrub-carrs we

surveyed the most problematic invasive species were autumn olive (*Elaeagnus umbellata*) and multiflora rose (*Rosa multiflora*). The use of fire to discourage invasive species and promote native species is especially encouraged, particularly for enhancing the heliophytic herbaceous species in the shrub-carrs (Reuter 1985; Warners 1989, 1997). Preservation of the Lowell Regional Greenspace wetlands, in concert with the B. D. White Shrub-Carr, allows for connections by offering cross-pollination as well as shared seed dispersal opportunities toward maintaining the genetic health of these outstanding wetland habitats.

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***SOLIDAGO PSAMMOPHILA* (ASTERACEAE: ASTEREA),
A NEW SAND DUNE ENDEMIC GOLDENROD
FROM NORTHERN MICHIGAN, U.S.A.**

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ABSTRACT

Solidago psammophila is described as a new species from open dune habitats along the southern shore of Lake Superior in Michigan's Upper Peninsula. Field and herbarium studies revealed that it is endemic to the state of Michigan, restricted to an approximately 100 km section of shoreline from Grand Sable Dunes in the west to Whitefish Point in the east. This goldenrod is ecologically similar to *S. gillmanii* (A. Gray) Steele in *Solidago* subsect. *Humiles* (Rydb.) Semple, sharing apparent adaptations to the sand dune environment. However, it differs from *S. gillmanii* and other members of subsect. *Humiles* in its vegetative pubescence and lack of glutinosity. It is morphologically most similar to the widespread *S. hispida* Muhl. in subsect. *Erectae* (G. Don) Semple & J.B. Beck. DNA ploidy determinations from flow cytometry revealed that this newly described species is tetraploid, whereas *S. hispida* has been shown to be uniformly diploid across its range. *Solidago psammophila* appears to be an example of the interplay of polyploidy and habitat specialization leading to ecological speciation in the recently glaciated Great Lakes region. A brief discussion of the other Great Lakes region endemic goldenrods and a revised key to all Michigan *Solidago* species are included.

KEYWORDS: endemism, goldenrod, Great Lakes region, polyploidy, *Solidago*

INTRODUCTION

The North American Great Lakes region, defined here as the area within the Great Lakes drainage basin, was completely glaciated during the most recent periods of Pleistocene glaciation (Dorr and Eschman 1970; Williams et al. 1998). In geologic terms, therefore, the contemporary flora of the region is young, having assembled only within the last 10,000 to 15,000 years. Most of the native vascular flora—ca. 2,500 species (Peirson 2010)—consists of species that migrated into the region following glaciation and that inhabit basic vegetation formations within the region. However, approximately 60 endemic vascular plant taxa have been described from the region. Unlike most widespread members of the flora, many of these endemics are restricted to ecologically specialized habitats, often along the shores of the Great Lakes (Peirson 2010).

The three best known Great Lakes shoreline endemics are *Iris lacustris* Nutt. (dwarf lake iris), *Solidago houghtonii* Torr. & A. Gray (Houghton's goldenrod), and *Cirsium pitcheri* Torr. & A. Gray (Pitcher's thistle), all of which are federally-listed threatened species. *Iris lacustris* and *S. houghtonii* both have geographic distributions that are tightly centered around the Straits of Mackinac in northern Michigan, a general distribution that is shared by a number of Great

Lakes endemics. *Iris lacustris* is restricted to calcareous shores and alvar habitats of the Niagara Escarpment from eastern Wisconsin and northern Michigan to the Bruce Peninsula in Ontario (Guire and Voss 1963; Trick and Fewless 1984), while *S. houghtonii* is likewise essentially confined to sandy and rocky shores from northern Michigan along the northern edge of Lake Huron to the Bruce Peninsula (Guire and Voss 1963; Morton 1979; Morton and Venn 2000; Laureto and Barkman 2011). The distribution of *Cirsium pitcheri*, while still encompassing the Straits of Mackinac, is broader than those of the previous two species. Pitcher's thistle inhabits beaches and active sand dunes from the southern shores of Lake Michigan north through Lake Huron, with several populations along the Lake Superior shoreline as well (Guire and Voss 1963; Voss 1996). Taken together, these three endemics illustrate the characteristic ecogeographic patterns found in a number of Great Lakes shoreline endemics (Peirson 2010).

Another striking Great Lakes shoreline endemic is Gillman's goldenrod or dune goldenrod, treated here at the species level as *Solidago gillmanii* (A. Gray) Steele (following Semple and Peirson 2013). Like *Cirsium pitcheri*, this species is a characteristic component of sand dune vegetation along the shores of Lake Michigan and northern Lake Huron. Gray (1882) originally described this goldenrod (at the time as *S. humilis* Pursh var. *gillmanii* A. Gray), as occurring on "sand hillocks on the shores of Lakes Superior and Michigan." Voss (1996) likewise included dune goldenrods along the southern shore of Lake Superior in *S. gillmanii* (at the time as *S. simplex* Kunth var. *gillmanii* (A. Gray) Ringius), even using a photograph of a particularly robust Lake Superior plant from Chippewa County, Michigan in his Plate 7F. However, during fieldwork to sample populations of *S. gillmanii* near Deer Park, Luce County, Michigan, as part of a broader phylogeographic study of the species and other members of *Solidago* subsect. *Humiles* (Rydb.) Semple, it became apparent that these Lake Superior dune goldenrods did not fit well within *S. gillmanii* from the dunes of Lakes Michigan and Huron. While the plants shared the overall form and apparent sand dune adaptations of *S. gillmanii*, the Lake Superior plants had conspicuous pubescence on both the leaves and the stems, a characteristic not found in *S. gillmanii*. They also lacked the glutinous (sticky) leaves and capitula (flower heads) of *S. gillmanii*. It was clear that these dune goldenrods warranted a closer look.

The major objectives of this study were (1) to use field and herbarium studies to examine the Lake Superior dune goldenrod and describe its distribution and ecology; (2) to compare this dune goldenrod to other goldenrods in the Great Lakes region and to assess its taxonomic placement; (3) to use flow cytometry to determine its ploidy; and (4) to use the information thereby collected to place it more broadly in the context of the endemic flora of the region.

MATERIALS AND METHODS

Study System—*Solidago* L. (Asteraceae: Astereae) is a genus of over 130 species of perennial herbs, approximately 120 of which are native to North America (Semple and Cook 2006; Semple 2022). Michigan is home to 27 currently recognized species of goldenrod (as summarized from Voss and Reznicek 2012; Semple and Peirson 2013; Semple et al. 2017a). The most recent classifications of the genus have recognized four subgenera, 15 sections, and 12 subsections, based on morphology and a polygenomic DNA phylogeny (Semple and Beck 2021; Semple et al. 2022, submitted). To

TABLE 1. Locality and voucher information for populations of Lake Superior dune goldenrod and *S. hispida* sampled for flow cytometry analyses. All populations were in Michigan, U.S.A. Vouchers are deposited at MICH.

Taxon	County	Latitude	Longitude	Voucher
Population				
<i>S. hispida</i> var. <i>hispida</i>				
Au Train Bay	Alger	46.43	−86.83	Peirson 853
Superior Campground Beach	Luce	46.68	−85.75	Peirson 856
<i>S. hispida</i> var. <i>huronensis</i>				
Great Sand Bay	Keweenaw	47.45	−88.22	Peirson 627
Lake Superior dune goldenrod				
East of Deer Park	Luce	46.68	−85.61	Peirson 861
East of 3-Mile Creek	Luce	46.73	−85.32	Peirson 833
Superior Campground Beach	Luce	46.68	−85.75	Peirson 855
West of Whitefish Point	Chippewa	46.79	−84.99	Peirson 857

date, no comprehensive molecular phylogenetic framework has been published for *Solidago*. The genus is well known for its complex patterns of infraspecific cytogeographic variation, with approximately 46% of recognized species showing some incidence of polyploidy in their histories (Peirson et al. 2012).

Goldenrods are characteristic members of the late summer- and fall-blooming floras across much of North America. Their most commonly yellow-rayed heads are arranged into conspicuous capitulescences in many species and can be quite showy. Goldenrods are self-incompatible and are pollinated by a variety of insect pollinators (Gross and Werner 1983; Haverkamp and Whitney 1983). Seed dispersal in *Solidago* species is by wind; the cypselae have a bristly pappus that aids in wind dispersal (Hood and Semple 2003).

Field Investigations—Fieldwork was conducted along the southern Lake Superior shoreline in Michigan. Sand dune and shoreline communities were surveyed from Marquette in Marquette County to Whitefish Point in Chippewa County. Populations of the Lake Superior dune goldenrod were located and sampled along a 75-km shoreline transect from Superior Campground Beach east of Grand Marais to Whitefish Point. Locality and voucher information is presented in Table 1. In addition to the target species, individuals of *S. hispida* Muhl. from the southern shore of Lake Superior were also sampled for comparison. At each site, rhizome cuttings from widely spaced individuals (clones spaced > 3 m apart) were harvested in the field and transplanted to Matthaei Botanical Gardens at the University of Michigan. The cuttings, consisting of a rosette of leaves and approximately four cm of rhizome with multiple nodes and buds, were potted in standard potting soil. Voucher specimens were harvested in the field, or taken from greenhouse-grown plants if not flowering in the field, and deposited in the University of Michigan Herbarium (MICH).

Herbarium Investigations—To determine the full geographic range of the species and to compare it to other sand dune endemic goldenrods in the Great Lakes region, *Solidago* specimens from GH, MICH, MO, MSC, MT, TEX, and UMBS were studied.

DNA Ploidy Determination—DNA ploidy (sensu Hiddeman et al. 1984) was determined by flow cytometry after the relative DNA content (from flow cytometry) was calibrated with chromosome counts and flow cytometry determinations from other studies (see below). At least one calibration/standardization was used for each recovered DNA ploidy level (2x and 4x). Similar methods have been used successfully for other species of *Solidago* (Halverson et al. 2008; Schlaepfer et al. 2008; Laureto and Pringle 2010; Peirson et al. 2012).

Methods follow those described in Peirson et al. (2012). Fresh *Solidago* leaf material was harvested from greenhouse-grown plants and stored in cool conditions for up to one week. For each sample, approximately one half of a young leaf was chopped with a clean razor blade in 0.8 ml ice-cold LB01 buffer (Doležel et al. 1989) with 50 µg/ml propidium iodide and 50 µg/ml RNase added. An approximately equal amount of fresh leaf from *Glycine max* (L.) Merr. ‘Polanka’ was co-chopped as an internal DNA content standard (2.5 pg/2c; cited in Doležel et al. 1994; Doležel et al. 2007). After chopping, each sample was filtered through a 30-µm filter into a microcentrifuge tube. Filtered

samples were then centrifuged. The supernatant was subsequently removed, and the pellet was re-suspended in 50 µg/ml propidium iodide and incubated at room temperature for 20-45 minutes. Samples were run on a BD FACSCalibur flow cytometer in the Department of Integrative Biology at the University of Guelph. Samples were run at medium pressure for 90 seconds, and data were acquired using CellQuest Pro software (BD Biosciences).

Samples were analyzed using Modfit (Verity Software) to estimate peak means, CVs (coefficients of variation), and nuclei number. DNA content was calculated as:

$$\text{DNA Content} = 2.5 \times \frac{\text{Solidago mean}}{\text{Glycine max mean}}$$

where 2.5 equals the standardized mean genome size of *Glycine max* (in pg/2C) and the other mean values represent the experimentally determined values for each sample and where pg/2C is the mean nuclear DNA content in picograms expressed on a diploid basis.

RESULTS AND DISCUSSION

Study of herbarium specimens from dune systems along the southern shore of Lake Superior supported the preliminary conclusion based on initial field observations that the goldenrods there differed from *Solidago gillmanii* and likely did not belong to *Solidago* subsect. *Humiles*, to which *S. gillmanii* belongs. The Lake Superior dune goldenrods shared the overall form and apparent sand dune adaptations of *S. gillmanii* (e.g., presence of elongate vertical rhizomes that allow survival from sand burial) but differed noticeably in their pubescent stems and foliage. Vegetative pubescence (outside of the floral arrays) is not found in *S. gillmanii* or the other members of subsect. *Humiles*. Subsequent fieldwork along the southern shore of Lake Superior confirmed the earlier observations. Plants in these populations were consistently pubescent (rarely only sparsely so) and were also not noticeably glutinous. Sticky leaves, stems, and capitula have been used as defining characteristics of members of subsect. *Humiles* sensu lato and are readily apparent in *S. gillmanii* in the field.

The vegetative pubescence and virgate (wand-like) inflorescences of the Lake Superior dune goldenrods suggested a possible relationship with *Solidago hispida* Muhl. (hairy goldenrod). That species is widespread throughout eastern North America, extending as far west as the Canadian prairie provinces, in a variety of dry, often sandy or rocky habitats (Semple et al. 2017b). The typical pubescent form of *S. hispida* occurs throughout Michigan. In the Lake Superior region, it occurs along the shore in open, sandy woods, on lakeshore bluffs, and in rock outcrop habitats, but is almost never present on the open dunes (except occasionally at the margins in more stabilized areas). Examination of plants in the field and the herbarium revealed that typical *S. hispida* seems to lack the elongate vertical rhizomes that would allow for survival from sand burial in open dune habitats. While sharing vegetative pubescence and virgate inflorescences, the Lake Superior dune goldenrods differed morphologically from nearby, typical *S. hispida* in their larger stature, clump-forming habit of several to many stems, elongate vertical rhizomes, and in their larger capitula (ca 6.5 mm vs ca 4.5 mm long, respectively). These observations supported the idea that these dune goldenrods along the southern shore of Lake Superior represented an un-

TABLE 2. DNA content and DNA ploidy as determined by flow cytometry analysis of fresh leaf tissue from *Solidago psammophila* and *S. hispida*.

Taxon	Population	No. Individ.	DNA Ploidy	DNA Content (pg/2C)		
				Mean (± SD)	Min.	Max.
<i>S. hispida</i> var. <i>hispida</i>						
	Au Train Bay	19	2x	2.09 (0.03)	2.04	2.15
	Superior Campground Beach	5	2x	2.07 (0.01)	2.06	2.09
<i>S. hispida</i> var. <i>huronensis</i>						
	Great Sand Bay	2	2x	2.12 (0.01)	2.12	2.13
<i>S. psammophila</i>						
	East of Deer Park	31	4x	4.37 (0.11)	4.16	4.60
	East of 3-Mile Creek	5	4x	4.27 (0.07)	4.19	4.36
	Superior Campground Beach	21	4x	4.36 (0.07)	4.22	4.49
	West of Whitefish Point	14	4x	4.26 (0.08)	4.16	4.40

described species that was possibly aligned with *S. hispida* and subsect. *Erectae* (G. Don) Semple & J. B. Beck.

In some *Solidago* complexes, ecogeographic separation and/or morphological differences (e.g., the size of the capitula) have also been associated with differences in ploidy level (as discussed in Peirson et al. 2012). Given the observed habitat and morphological differences between the dune goldenrods, hereafter referred to *S. psammophila*, and nearby *S. hispida*, this study also examined if there were differences in ploidy as well. DNA ploidy determinations from flow cytometry were obtained for 71 individuals from four populations of *S. psammophila* and for 26 individuals from three populations of *S. hispida* from the Lake Superior shore (Tables 1 and 2). Flow cytometry recovered two non-overlapping DNA ploidy groups that correspond to diploid ($2x = 18$) and tetraploid ($4x = 36$) individuals (Table 2; Figure 1). All sampled individuals of *S. psammophila* were found to be tetraploid, whereas individuals of *S. hispida* were found to be uniformly diploid. The $2x$ and $4x$ DNA ploidy groupings from this study are consistent with groupings found in previous flow cytometry studies of other *Solidago* species (e.g., Halverson et al. 2008; Schlaepfer et al. 2008; Peirson et al. 2012). The diploid determination for *S. hispida* is also consistent with previous cytological studies of the species (as summarized from Semple and Cook 2006; Semple et al. 2017b). *Solidago psammophila* would be the second tetraploid in the *S. bicolor*–*S. hispida* complex, after the upper Midwest endemic *S. sciaphila* Steele (following Semple et al. 2017b). Whether *S. psammophila* formed through chromosome doubling within a single *S. hispida*-like ancestral species (autopolyploidy) or as a result of hybridization and subsequent chromosome doubling (allopolyploidy) was not examined in this study. The narrowly circumscribed distribution along a short portion of the southern shore of Lake Superior suggests a single origin of *S. psammophila*.

Given that Gray’s (1882) original concept of *Solidago humilis* var. *gillmanii* was mixed and included both the Lake Michigan/Lake Huron dune plants and the Lake Superior *S. psammophila*, scrutiny of the original description and the type of *S. gillmanii* was necessary. Gray stated in his description that *S. humilis* var. *gillmanii* was “an extreme form of this variable species, with dentate even

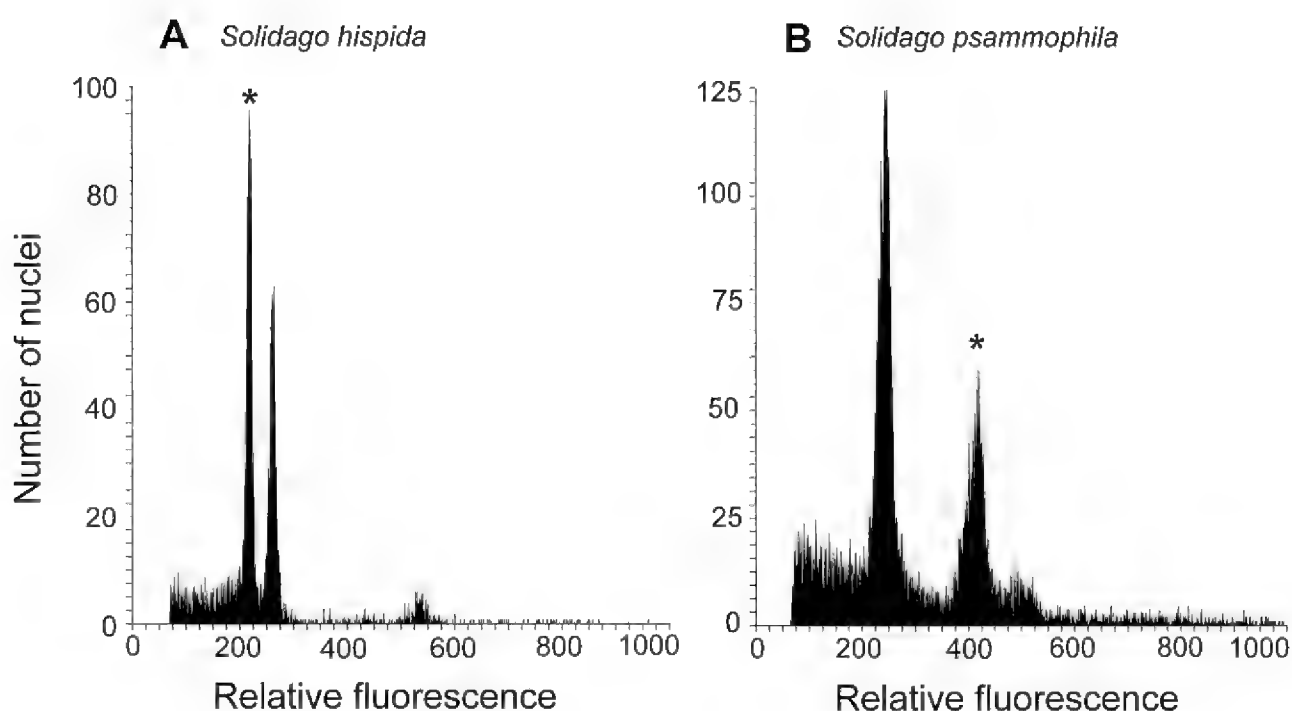


FIGURE 1. Representative fluorescence histograms of stained nuclei isolated during flow cytometry analyses of fresh tissue of *Solidago psammophila*, *S. hispida*, and the internal standard (*Glycine max* 'Polanka'). The *Solidago* peak is indicated by an asterisk (*). (A) diploid *S. hispida* from Superior Campground Beach, Luce County, Michigan; (B) tetraploid *S. psammophila* from Deer Park, Luce County, Michigan.

laciniate leaves and an open compound panicle; growing on sand hillocks on the shores of Lakes Superior and Michigan.” Gray, however, did not cite any collections or designate a type for var. *gillmanii*. As follow-up to his biosystematic study of the “*S. spathulata*–*S. glutinosa* complex,” which included *S. gillmanii*, Ringius (1987) reviewed the nomenclature of the group and designated a number of lectotypes, including for *S. humilis* var. *gillmanii*. Ringius’ choice of lectotype, at first glance, presented a bit of a quandary. He stated that there were three collections from “the south shore of Lake Superior . . . sent to A. Gray by W. Boott” and identified by Gray as var. *gillmanii* that could serve as candidates for the lectotype (two 1875 collections (GH, NY) and a single 1879 collection (GH)). Ultimately, Ringius designated the 1879 GH collection as lectotype and stated that it matched “the protologue in having laciniate leaf margins and an open compound panicle.” Examination of the 1875 and 1879 collections, however, revealed that the 1879 collection designated as lectotype by Ringius was not a plant from the Lake Superior shore.

The labels on the 1875 GH collection indicate “s. Shor l. Superior root sent by W. Boott.” Examination of that collection, which consists of two sheets with portions of the same rosette (GH-00274538, GH-00274539), revealed sparse pubescence on the rosette leaves as well as capitula that did not appear glutinous. Similarly, examination of a digital image of the NY collection (NY-02369465) also appears to show pubescence on the rosette leaves and an overall lack of glutinosity. The pubescence on the foliage, the lack of glutinosity, and the label data indicating that the collections originated from the southern shore of Lake Superior confirm that the 1875 collections are *Solidago psammophila*. The label

on the lectotype, the 1879 GH collection (00012486), indicates “Roots from upper Michigan by W. Boott” and “same as 1875.” Examination of the lectotype did not reveal any vegetative pubescence outside of the floral array. In addition, the capitula and leaves within the capitulescence appear to have been glutinous (e.g., they have a slightly varnished/resinous appearance). Morphologically, the 1879 collection is a characteristic, cultivated specimen of *S. gillmanii*, consistent with plants cultivated from Lake Michigan dune systems at the Matthaei Botanical Gardens during this and previous studies. Ringius (1987) stated that the 1879 GH collection was from the south shore of Lake Superior, presumably inferring that the notation on the label of “same as 1875” indicated that the specimen was from the same plant. Examination of the collections revealed that this cannot be correct, since the 1875 and 1879 collections represent *S. psammophila* and *S. gillmanii*, respectively. By “same as 1875” Gray presumably simply meant that he considered the collections to represent the same taxon. In addition, the locality information of “upper Michigan” on the label would indicate that the collection came from Michigan’s Upper Peninsula, not specifically that it came from the Lake Superior shore, and Gray did include “Lake Michigan” in the original description. The lectotype of *S. gillmanii* originated from the dunes along northern Lake Michigan/Huron in Michigan’s Upper Peninsula. *Solidago gillmanii* is quite common on the dunes there and absent from the Lake Superior shore, so far as is known.

TAXONOMIC TREATMENT

Solidago psammophila J.A. Peirson, sp. nov.—TYPE: U.S.A. Michigan: Alger Co., Sect. 7, ca. 6 miles west of Grand Marais, high dunes above Lake Superior, July 26, 1948, *McVaugh 9586* (holotype: MICH!, isotypes: MT!, UMBS!).

Perennial herbs from branching vertical rhizomes or caudices. Stems 1 to ca. 15, 35–75 cm, ascending or more commonly erect (occasionally slightly decumbent at base), generally unbranched below the capitulescence, sparsely to densely hispid or short-villous proximally, occasionally appearing glabrate, especially if trichomes have been abraded by blowing sand, moderately to densely hispid to strigose in the capitulescence. Leaves alternate, simple, petiolate or sessile, sometimes stipitate glandular (but not becoming resinous or glutinous), moderately or sparsely short-pubescent to sericeous or more rarely strigose. Basal rosette and proximal stem leaves petiolate, petiole ciliate, blade ovate-ob lanceolate to narrowly oblanceolate, tapering to petiole, 4–14 cm long, 0.7–3 cm wide, apex acute to obtuse or less often rounded, margin serrate. Mid and distal stem leaves sessile, lanceolate to linear, 1–4 cm long, 0.2–0.6 cm wide, reduced upward, margin entire or sparsely serrate. Capitulescence narrowly to broadly elongate-paniculiform, 7–25 cm long, 2.5–8.5 cm wide, consisting of short axillary and terminal racemiform clusters, lower branches occasionally elongated in larger plants, branches strigulose; heads few to numerous, not secund. Peduncles 3–10 mm long, strigulose; bracteoles few, linear. Involucres



FIGURE 2. *Solidago psammophila*. Holotype McVaugh 9586 (MICH). Inset shows close-up of leaves (A), capitula (B), and cypselae (C).

campanulate, 5–8.1 mm long. Phyllaries in 3–4 graduated rows, the outer ones ovate, the inner ones linear-oblong, apex acute to obtuse or rounded, often ciliate or fringed. Ray florets 8–13, strap-shaped, 2–3 mm long, 0.6–0.9 mm wide. Disc florets 8–15, corollas 3.5–5 mm long. Cypselae narrowly obconic, antrorse-strigose, ca. 3 mm long. $2n = 36$ (from DNA ploidy determination). (Figure 2).

Etymology. The specific epithet *psammophila*, which means sand-loving, refers to the restricted ecological distribution of the species in open dune habitats.

Phenology. Plants generally begin flowering in early August and continue until late September. Cypselae mature and are dispersed from mid-September through October.

Distribution and Ecology. *Solidago psammophila* is restricted to active sand dunes along the southern shore of Lake Superior in Alger, Chippewa, and Luce Counties, Michigan (Figures 3 and 4). Populations of the species occur along an approximately 100 km length of shoreline from Grand Sable Dunes in the west to Whitefish Point in the east. No additional populations have been located along the Lake Superior shoreline west of Grand Sable Dunes. *Solidago psammophila* is a component of the open dune community (following Kost et al. 2007) and is commonly associated with other open dune species such as *Ammophila breviligulata* Fern., *Artemisia campestris* L., and *Arctostaphylos uva-ursi* (L.)

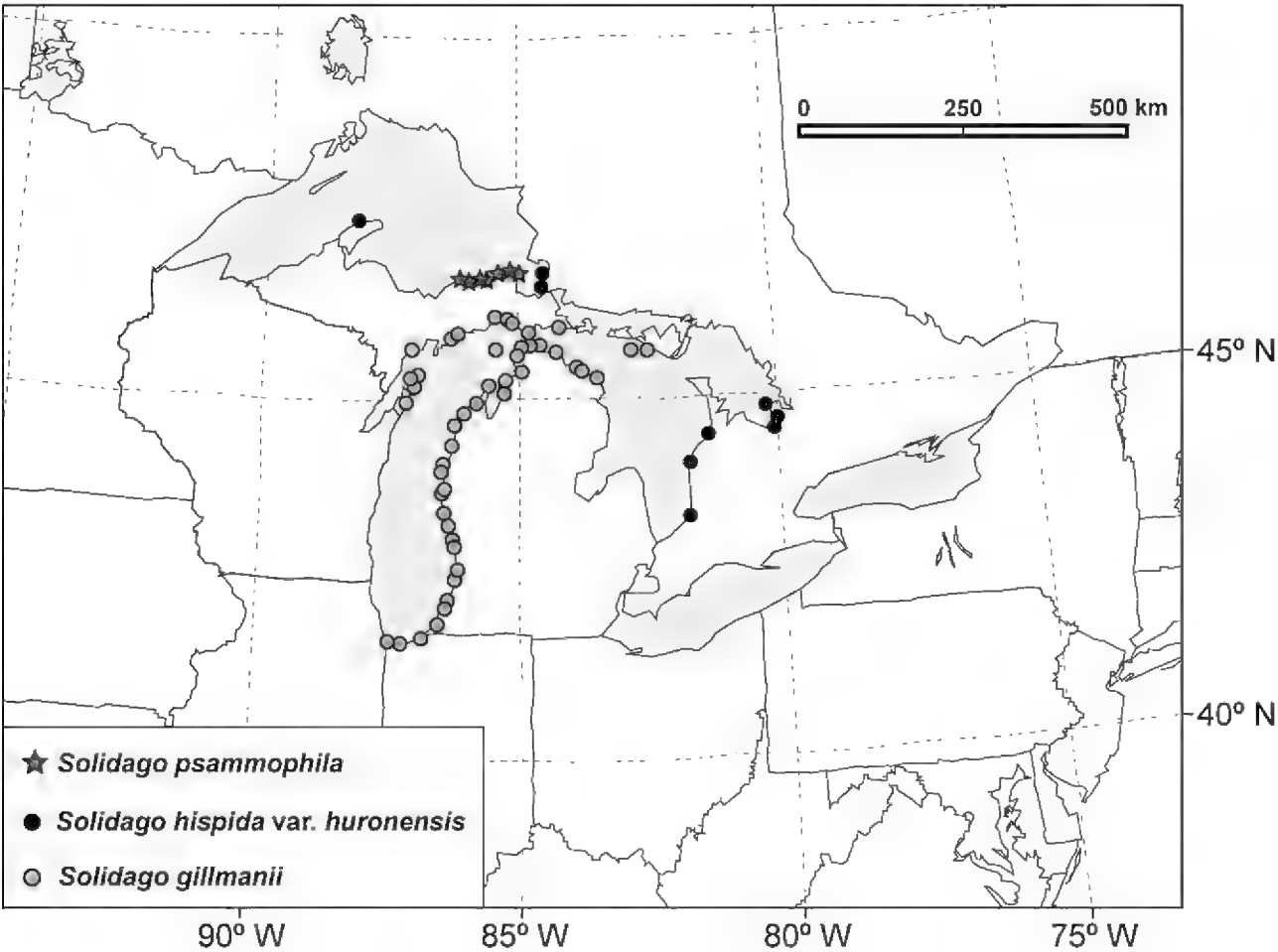


FIGURE 3. Distribution of sand dune endemic goldenrods in the North American Great Lakes region: *Solidago gillmanii* (gray circles), *S. hispida* var. *huronensis* (black circles), and *S. psammophila* (gray stars). Distributions based on the current study, Semple et al. (1999), and Peirson (2010).



FIGURE 4. Open dune habitat of *Solidago psammophila* along the southern shore of Lake Superior, east of Deer Park, Luce County, Michigan.

Spreng. It is less frequently found at the periphery of more stabilized areas like Great Lakes barrens and bluffs adjacent to open dune habitats.

Adaptation to the Dune Environment. The sand dune environment exerts strong selection on plants that grow there (e.g., through factors like nutrient deficiency, drought, and recurrent sand burial), and sand dune specialists have developed adaptations to survive the extreme environment (Maun 1994, 1998). *Solidago psammophila* produces elongate vertical rhizomes that appear to be apparent adaptations to help survive sand burial. Greenhouse germinated and grown seedlings of *S. psammophila*, as well as those of *S. gillmanii*, produce elongate vertical stems below the rosette of leaves during the first year of growth, without any exposure to burial by sand. Contrastingly, greenhouse germinated and grown seedlings of the widespread *S. glutinosa* Nutt. from northern Michigan sand barren sites (where there is little or no sand movement) do not produce elongate vertical stems. Field observations from dune systems throughout the Great Lakes region have shown that some widespread species of *Solidago* commonly occur at the margins of the open dune habitat where the sand has become stabilized. These species, which presumably lack specific adaptations, are essentially absent from the inhospitable open dune environment.

DNA Ploidy. Data from flow cytometry showed *Solidago psammophila* is uniformly tetraploid ($4x = 36$) across its range (Table 2).

Additional Specimens Examined. U.S.A., MICHIGAN: S. shore of Lake Superior, 1875, *W. Boott s.n.* (GH); ALGER COUNTY: Grand Sable Dunes west of Grand Marais, T49N R14W sec. 10, 24 Sept 1964, *R.C. Harris s.n.* (MSC);

Grand Sable Dunes, on the open dunes N of Grand Sable Lake, 5 Sept 1999, *M. Chamberland 1306* (MSC); ca. 2.5 mi W of Grand Marais, common on sand dunes just N of Grand Sable Lake, 10 Aug 1954, *E.G. Voss 2477* (MICH); open sandy area on Grand Sable Dunes, N of Grand Sable Lake, 3 Aug 1975, *D. Bach 22* (MICH); CHIPPEWA COUNTY: west of Whitefish Point, plants common on stabilized and active sand dunes, 21 Aug 2010, *J. A. Peirson 857* (MICH); Vermillion, along Lake Superior, upper beach and dunes, 9 Sept 1951, *H.H. Bartlett & C.D. Richards 320* (MICH); near Vermillion, sandy beach of Lake Superior shore, 31 Aug 1914, *C.K. Dodge s.n.* (MICH); Whitefish Point, growing on shingle beach, 1 Aug 1977, *W.T. Gillis 14073* (MSC—2 sheets); Whitefish Point, growing on shingle beach, 1 Aug 1977, *W.T. Gillis 14074* (MSC); Whitefish Point, near Lake Superior, sparsely wooded dune-marsh area, on open dune, 9 Aug 1948, *R. McVaugh 9768* (MICH, UMBS); LUCE COUNTY: ca. 1 mile east of Deer Park, active sand dunes on lake Superior, 24 Aug 2006, *J. A. Peirson 638* (MICH); ca. 1 mile E of Deer Park, on sand dunes along Lake Superior shore, active sand dunes and somewhat stabilized sand toward base of bluff, 11 Sept. 2010, *J.A. Peirson 861* (MICH); ca. 3-4 miles E of Deer Park, plants common on dunes along lake Superior, 25 Aug 2006, *J. A. Peirson 641* (MICH); mouth of Three-mile Creek east along Lake Superior shore to Crisp Point Lighthouse, off of Luce County 412, plants common on active sand dunes and in dry, stabilized, interdunal meadows, 5 Sept 2008, *J. A. Peirson 833* (MICH); east of the mouth of Three-mile Creek along Lake Superior shore, plants common on active sand dunes, 22 Aug 2021, *J. A. Peirson 923* (MICH); Lake Superior Campground Beach, off of County Road 407 between Grand Marais and Deer Park, plants common along road and on stabilized sand bluff and more active dunes, 21 Aug 2010, *J. A. Peirson 855* (MICH); near E edge of Sect. 3, T49N R10W, ca. 4 miles E of Deer Park, frequent, low dune ridge above Lake Superior, 21 Aug 1978, *E.G. Voss 15011* (MICH); County Rd. 407, at mouth of Blind Sucker River, in coastal sand dunes, 27 Aug 1993, *H.H. Schmidt & M. Merello 1074* (MO, MIN (online image), TEX).

BRIEF NOTES ON ENDEMIC *SOLIDAGO* TAXA IN THE GREAT LAKES REGION

In addition to *Solidago psammophila* and *S. gillmanii*, four other goldenrods have commonly been recognized as endemic to the glaciated North American Great Lakes region. Except for *S. hispida* var. *huronensis* Semple, which is diploid, all recognized Great Lakes endemic taxa of *Solidago* are polyploid (Table 3). Like the majority of the broader endemic flora, these *Solidago* taxa have distributions centered in the northern parts of the region. They are restricted to regionally rare, non-forested habitats that are linked to present and/or past Great Lakes shorelines (Peirson 2010).

***Solidago hispida* var. *huronensis*.** This taxon, along with *Solidago psammophila* and *S. gillmanii*, constitute the three sand dune endemic goldenrods that occur in the Great Lakes region. *Solidago hispida* var. *huronensis* is most com-

TABLE 3. Distribution, habitat, and ploidy of endemic taxa of *Solidago* in the glaciated North American Great Lakes region. Data summarized from Laureto and Pringle (2010), Peirson et al. (2012), Semple et al. (1999), Semple and Cook (2006), Voss and Reznicek (2012), and the current study.

Taxon	Ploidy	Distribution	Habitats
<i>Solidago gillmanii</i>	4x = 36	Lakes Huron and Michigan shoreline	Open dunes
<i>Solidago hispida</i> var. <i>huronensis</i>	2x = 18	Lakes Huron and Superior shoreline	Open dunes
<i>Solidago houghtonii</i>	6x = 54	Lakes Huron and Michigan shoreline	Interdunal swales, sandy shores, alvars
<i>Solidago ontarioensis</i>	4x = 36	Lakes Huron, Michigan*, and Superior shoreline	Rock outcrops
<i>Solidago psammophila</i>	4x = 36	Lake Superior shoreline	Open dunes
<i>Solidago vossii</i>	8x = 72	Northern Lower Peninsula of Michigan (former postglacial shoreline)	Moist, sandy swales (inland)

*A population of *Solidago ontarioensis* on limestone bedrock at Seul Choix Point, Schoolcraft County, Michigan, is the only occurrence of the species along the Lake Michigan shoreline.

mon on active dune systems along the Canadian shores of Lake Huron, including Georgian Bay, but it also occurs along the shores of Lake Superior (both along the southeastern shore in Canada and on Michigan’s Keweenaw Peninsula in western Lake Superior). Whereas *S. psammophila* and *S. gillmanii* are cohesive, morphologically well-defined tetraploid species, diploid *S. hispida* var. *huronensis* appears to intergrade with more typical *S. hispida* along the open-dune to stabilized-dune transition at some locations. Glabrous plants that are most common on sparsely vegetated open dunes tend to be replaced by sparsely pubescent plants along the back-dune, which are in turn replaced by typical *S. hispida* individuals where the dunes become stabilized (J. Peirson, personal observations from Great Sand Bay, Keweenaw County, Michigan and Pinery Provincial Park, Ontario). The evolution of this Great Lakes endemic has not been closely studied, but Semple et al. (2017b) proposed that it likely represents an ecotype adapted to local conditions (possibly including sandy habitats further east in Ontario). Given its scattered, disjunct distribution, it seems plausible that this form may have evolved multiple times in response to site-specific edaphic conditions.

***Solidago houghtonii*.** Douglas Houghton first collected the flat-topped, large-headed *Solidago houghtonii* along the shores of northern Lake Michigan in Mackinaw Co., Michigan, on August 15, 1839 (Voss 1978). One of the best-known Great Lakes endemics, this hexaploid goldenrod is restricted to sandy and rocky shores and interdunal hollows of northern Lakes Michigan and Huron (Guire and Voss 1963; Morton 1979; Morton and Venn 2000; Laureto and Barkman 2011). A disjunct population in the Bergen Swamp, Genesee Co., New York has often been included in *S. houghtonii* (Guire and Voss 1963; Semple and Cook 2006; Laureto

and Barkman 2011); however, its relationship to populations within the main Great Lakes distribution has not been definitively studied. Morton (1979) proposed that hexaploid *S. houghtonii* is an allopolyploid derivative of a cross between *S. ohioensis* Riddell ($2n = 18$) and *S. ptarmicoides* (Torr. & A. Gray) Boivin ($2n = 18$) with a subsequent backcross to *S. ohioensis*, whereas Semple et al. (1999) proposed that *S. riddellii* Frank may be involved in its origin. Laureto and Barkman (2011) suggested, based on chloroplast DNA sequence data, that *S. gigantea* Ait. was the maternal genome donor. Extensive cpDNA haplotype sharing within *Solidago*, however, has posed challenges for elucidating relationships within the genus more generally (e.g., Peirson et al. 2013).

***Solidago vossii*.** Inland populations of a flat-topped, large-headed goldenrod in northern Michigan (Crawford County) that had historically been included in *Solidago houghtonii* were recently described as *S. vossii* J.S. Pringle & Laureto (Laureto and Pringle 2010). The octoploid *S. vossii* is more robust and has larger involucres and ray florets than *S. houghtonii*. While its present distribution is inland, the locale lies along the shores of postglacial Lake Margrethe. The species occurs in a distinct wet sand prairie habitat that includes a mixture of plants common to mesic prairies as well as some species characteristic of Great Lakes interdunal wetlands (Laureto and Pringle 2010). Like *S. psammophila*, *S. vossii* is endemic to the state of Michigan.

***Solidago ontarioensis*.** This tetraploid endemic, recognized at the species level by Semple and Peirson (2013), formerly *S. simplex* var. *ontarioensis* (Ringius) Ringius, is restricted to shoreline rock outcrop habitats in the northern Great Lakes region. Plants grown in a common garden suggest that *Solidago ontarioensis* (Ringius) Semple & Peirson comprises two phenotypically distinct sets of populations in the Great Lakes region (Peirson 2010). Large-statured plants occur on dolomite shores of northern Lake Huron and northern Lake Michigan, along the boundary of the Niagara Escarpment. Smaller-statured plants occur primarily on granite/basalt outcrops along the southern and eastern shores of Lake Superior. This distribution of phenotypes raises the possibility that *S. ontarioensis* encompasses two independently derived lineages. Phylogeographic data suggest that the two groups have separate origins (Peirson 2010; Peirson et al. 2013); however, extensive haplotype sharing has thus far precluded any concrete assessment of evolutionary relationships.

KEY TO THE SPECIES OF *SOLIDAGO* OCCURRING IN MICHIGAN, U.S.A.
(modified with permission from Voss and Reznicek 2012)

- 1. Heads in a terminal ± flat-topped corymbiform inflorescence.
 - 2. Blades of middle and upper cauline leaves ovate to elliptic (less than 3 times as long as broad), densely pubescent on both surfaces.....*S. rigida*
 - 2. Blades of middle and upper cauline leaves linear to lanceolate or oblanceolate (over 10 times as long as broad), glabrous or nearly so.
 - 3. Rays 12–18, white, 4.5–8 mm long; pappus hairs slightly but clearly thickened (slenderly clavate) toward tip; upper cauline leaves slightly oblanceolate (broadest above the middle)*S. ptarmicoides*
 - 3. Rays 10 or fewer, yellow, not over 4.5 (–7) mm long; pappus hairs not thickened (or some thickening scarcely visible in *S. houghtonii*); upper cauline leaves broadest at or below the middle.

4. Rays 1.5–3 mm long and involucre ca. 3.5–5.5 (–6.5) mm long; pedicels smooth and glabrous or rough-hispidulous.
 5. Pedicels smooth and glabrous or nearly so; leaf blades with one longitudinal vein (but often some principal lateral veins), flat*S. ohioensis*
 5. Pedicels and inflorescence branches densely rough-hispidulous; leaf blades with 3 or more longitudinal veins at the base, all or mostly complicate*S. riddellii*
4. Rays 3–4.5 (–7) mm long and involucre ca. 5–9 mm long; pedicels scabrous-hispidulous.
 6. Larger involucre 5–7 (–8) mm long; larger plants mostly 30–60 cm tall; basal leaves entire; hexaploid; plants occurring on or near the Great Lakes shores, centered on the Straits of Mackinac*S. houghtonii*
 6. Larger involucre 7–9 mm long; larger plants mostly 50–80 cm tall; basal leaves sparsely serrulate; octoploid; inland in swales among *Pinus banksiana**S. vossii*
1. Heads in an elongate or pyramidal inflorescence or in axillary clusters.
 7. Inflorescence terminal, often \pm pyramidal (broadest toward base, about equally long, slightly nodding at top) but sometimes grading into axillary branches, and with curving, one-sided branches (the heads mostly directed upwards on well-developed branches).
 8. Cauline leaves (at least the main ones) “triple-nerved,” i.e., with a pair of elongate veins arising below the middle of the midrib and distinctly stronger than other lateral veins.
 9. Leaves entire, succulent; saline habitats (e.g., edges of heavily salted roads)*S. sempervirens*
 9. Leaves with at least tiny and/or irregular teeth, of normal herbaceous texture; various habitats.
 10. Axis, pedicels, and branches of inflorescence glabrous; prairie and dry prairie-like habitats, blooming late in the season; lower and rosette leaves linear-lanceolate*S. missouriensis*
 10. Axis, pedicels, and branches of inflorescence at least sparsely but distinctly pubescent; or if glabrous (*S. juncea*), the lower and rosette leaves much larger than the mid-cauline leaves, \pm elliptic, and the plant blooming early in the season in dry habitats.
 11. Stem glabrous all of its length below the inflorescence, rarely with a few scattered, spreading, short hairs.
 12. Basal leaves none; cauline leaves narrowly (rarely broadly) elliptic and the lowest withered by flowering time; middle and upper cauline leaves crowded (numerous), about the same size as the lowest leaves or larger, and distinctly 3-nerved; plants blooming late (starting August–September); branches of inflorescence \pm densely pubescent*S. gigantea*
 12. Basal (including rosette) and lower cauline leaves with oblanceolate to elliptic blades and long petioles, persistent; middle and upper cauline leaves remote (relatively few), distinctly smaller than basal leaves, and only weakly 3-nerved; plants blooming early (starting in July); branches of inflorescence glabrous or occasionally sparsely spreading pubescent*S. juncea* (in part)
 11. Stem pubescent all or most of its length.
 13. Involucre all or mostly 3.1–4.6 (–5) mm long*S. altissima*
 13. Involucre all or nearly all 2–3 mm long*S. canadensis*
 8. Cauline leaves with distinct midrib but the other (weaker) veins \pm pinnate.
 14. Stems \pm pubescent, at least on the upper half of the plant.
 15. Cauline leaves entire or obscurely crenate-toothed; leaves and stems uniformly and densely puberulent throughout; lower and basal (including rosette) leaves oblanceolate, tapered into a winged petiole and larger than mid-cauline leaves; sandy or rocky, open and usually very dry soil*S. nemoralis*
 15. Cauline leaves sharply toothed; leaves beneath (at least on main veins) and stem with mostly spreading, longer hairs (over 0.5 mm); lower and basal

- leaves (none in rosettes) no larger than mid-cauline leaves (but usually absent at flowering time), all of them elliptic-lanceolate; moist or shaded ground*S. rugosa*
14. Stems glabrous (except sometimes just below and in the inflorescence).
16. Lowest cauline leaves with tapering base clasping stem (encircling it for at least half its circumference); wet habitats, with leaves nearly smooth above.....*S. uliginosa* (in part)
16. Lowest cauline leaves not clasping stem; dry habitats or, if wet, the leaves very scabrous above.
17. Stem with strongly raised angles or ribs; upper leaf surface very scabrous, with dense, tiny, stiff conical projections; swamps and other wet habitats*S. patula*
17. Stem terete (may be many-ridged); upper leaf surface smooth to slightly scabrous; ± dry open or forested habitats.
18. Basal (including rosette) and lower cauline leaves much larger than mid-cauline leaves, persistent (blades often 7–20 cm long on petioles half or more as long); branches of inflorescence glabrous or occasionally sparsely spreading-pubescent; leaves often tending to have prominent longitudinal veins, usually glabrous beneath but occasionally with some hairs on midrib; throughout Michigan, beginning to bloom in July (before other goldenrods)*S. juncea* (in part)
18. Basal and lower leaves often withered by flowering time or, if present, not much larger than mid-cauline leaves; branches of inflorescence rather densely pubescent; leaves clearly pinnate-veined, with midrib and principal veins beneath spreading-pubescent (as in *S. rugosa*); southern Lower Peninsula, blooming late*S. ulmifolia*
7. Inflorescence axillary or terminal, but even if pyramidal the branches not one-sided and the top not nodding.
19. Leaves decreasing in size from middle of stem to the base, the mid- to upper cauline leaves sharply toothed, much exceeding the distinctly axillary inflorescences (not necessarily any branches) they subtend; stems glabrous (except rarely on upper internodes), the lowest leaves usually withered by flowering time; achenes ± densely pubescent.
20. Leaf blades narrowly elliptic, sessile; stem terete, glaucous when fresh, not (or scarcely) zigzag; leaves glabrous (except for short-ciliate margin); cespitose...*S. caesia*
20. Leaf blades broadly ovate-elliptic, abruptly contracted to a winged petiole; stem ribbed or angled throughout, ± zigzag from node to node; leaves (at least the midrib beneath and petiole margins) ± sparsely pubescent; colonial from creeping rhizomes.....*S. flexicaulis*
19. Leaves increasing in size from middle of stem to the base, the mid-cauline leaves usually entire to crenate-toothed and usually not subtending inflorescences (these more clearly terminal); stems glabrous or pubescent, the lowest leaves usually persistent; achenes glabrous or glabrate (except in *S. psammophila* and the *S. glutinosa* group).
21. Stem sparsely to densely pubescent its entire length and leaves pubescent, at least abaxially.
22. Rays white or cream when fresh.....*S. bicolor*
22. Rays yellow
23. Stems usually numerous (5–8), from deep vertical rhizomes; involucre 5–8 mm long; achenes antrorse-strigose; tetraploid; active coastal sand dunes of Lake Superior.....*S. psammophila*
23. Stems solitary or few (1–3), from shallow caudices; involucre 3–4.5 mm long; achenes glabrous or glabrate; diploid; usually dry habitats, including margins of coastal sand dunes.....*S. hispida* (in part)
21. Stem glabrous at least below the middle and leaves generally glabrous.
24. Lower cauline leaves ca. 6–18 times as long as broad, the petiole clasping the stem for half or more of its circumference; plants occurring in wet habitats (including rock crevices on Lake Superior)*S. uliginosa* (in part)

24. Lower cauline leaves ca. 3–8 times as long as broad, not clasping (leaves of basal rosettes sometimes as much as 11 times as long as broad); plants occurring mostly in dry habitats.
25. Achenes antrorse-strigose; involucre and leaves resinous (more easily determined when fresh, but usually appearing varnished, shiny or glandular when dry).
26. Plants robust; stems from deep vertical rhizomes; petiole ciliate; plants flowering mid August to October; active coastal sand dunes of Lakes Huron and Michigan*S. gillmanii*
26. Plants relatively small; stems from shallow caudices; petiole usually not ciliate; plants flowering late June to mid August; coastal rock outcrops of Lakes Michigan and Superior or inland sand barrens.
27. Involucre 4.5–6.2 mm long; plants flowering mid July to mid August; tetraploid; coastal rock outcrops of the Upper Peninsula*S. ontarioensis*
27. Involucre 3.4–4.3 mm long; diploid; plants flowering late June to late July; inland sand barrens of the Lower Peninsula*S. glutinosa*
25. Achenes glabrous or glabrate; involucre and leaves not resinous.
28. Cauline leaves (3–) 5–15 (–17) below inflorescence; margins of lower and middle leaves crenulate; plants occurring on rock outcrops and dunes on Lake Superior and northern Lake Huron*S. hispida* (in part)
28. Cauline leaves ca. (11–) 15–30 below inflorescence; margins of lower and middle leaves entire to sparsely toothed in the upper half; plants occurring in prairies, jack pine plains, and oak barrens, sandy fields and rock outcrops (inland).
29. Basal rosette and lower stem leaves present at flowering; plants flowering from early July to late August; jack pine plains, sandy fields, and rock outcrops of the northern Lower Peninsula and western Upper Peninsula*S. jejunifolia*
29. Basal rosette and lower stem leaves absent at flowering; plants flowering September and October; prairies, sandy fields, and oak barrens of the southern half of the Lower Peninsula*S. rigidiuscula*

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NOTEWORTHY COLLECTION

SECOND EASTERN UNITED STATES RECORD OF *VIOLA EPIPSILA* LEDEB. SUBSP. *REPENS* W.BECKER (VIOLACEAE)

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Significance of the report. The boreal and arctic *Viola epipsila* Ledeb. subsp. *repens* W.Becker (Dwarf Marsh Violet, Figures 1 and 2) is reported for the second time in the eastern United States.

Previous knowledge. Subsection *Stolonosae* (Kupffer) Kupffer of Sect. *Plagiostigma* Godr., to which *Viola epipsila* Ledeb. subsp. *repens* W.Becker belongs, is the sixth largest infrageneric group in *Viola* with 41 species (Marcussen et al. 2022). Members of Subsection *Stolonosae*, often colloquially known as the “acaulescent white” violets, are distributed over the northern hemisphere and differ from other acaulescent violets in their slender rhizome, commonly stoloniferous habit, undivided leaf blades, membranous glandular-lacerate commonly non-adnate stipules, white or pale violet flowers with short thick saccate spur, style with margined and flattened apex, and base chromosome number of $x = 24$ (ancestrally allotetraploid, Marcussen et al. 2012). A recognizable assemblage of taxa in the *Stolonosae* is informally named the “Palustres” after the earliest published member *Viola palustris* L. “Palustres” violets share unusual features of creeping surficial rhizome (vs. horizontal to erect subterranean rhizomes) and lateral stoloniform rhizomes, leaves inserted separately behind the apical meristem (vs. leaves clustered into rosettes), pale violet or violet-tinged flowers (vs. white flowers), and ovate semi-sheathing stipules (vs. lanceolate non-sheathing stipules). Allopolyploidization events within and between “Palustres” and non-“Palustres” *Stolonosae* have produced various allo-octoploid derivatives; those involving at least one “Palustres” parent species have been retained in the “Palustres”.

The “Palustres” group is circumboreal and includes three tetraploid taxa (one in eastern Eurasia and North America, two in Eurasia) and three octoploid taxa (two in North America, and one circumboreal). The tetraploids consist of *Viola epipsila* subsp. *epipsila* in western Eurasia; *Viola suecica* Fr. in Europe; and *Viola epipsila* subsp. *repens* in eastern Eurasia and Alaska to western Ontario, southward into the Rocky Mountains and the northern Great Lakes region. Wilhelm Becker (1917) included *Viola suecica* in *Viola epipsila* and recognized two



FIGURE 1. *Viola epipsila* subsp. *repens* at Tombstone Territorial Park, Yukon Territory. Photo by Kim Blaxland, July 2009.

subspecies under *Viola epipsila*, subsp. *epipsila* and subsp. *repens*. Marcussen and others (unpublished) have found that *Viola epipsila* subsp. *epipsila* and *Viola suecica* in Eurasia are distinct and should be maintained as separate species, while *Viola epipsila* subsp. *repens* is conspecific with *Viola suecica*, not with *Viola epipsila* sensu stricto as Becker interpreted. *Viola suecica* sensu stricto and *Viola epipsila* subsp. *repens* are distinguishable and are best treated as subspecies; the name subsp. *repens* will require a future transfer to *Viola suecica*. Our North American tetraploid “Palustres” violet should be recognized in future at the species level as *Viola suecica* Fr., but it is retained under the familiar name of *Viola epipsila* in this announcement to avoid confusion.

Octoploid ($2n = 48$) members of the “Palustres” group are *Viola palustris* subsp. *palustris* in Europe and North America, southward into the Rocky Mountains and New England; *Viola pluviae* Marcussen, H.E. Ballard & Blaxland in the far western Rocky Mountains of North America; and *Viola palustris* subsp. *brevipes* M.S. Baker in the Rocky Mountains of southwestern Canada and western United States. Morphological, cytological and phylogenetic evidence urges elevation of subsp. *brevipes* to species rank in the future.

The first record of *V. epipsila* subsp. *repens* in the United States east of the Rocky Mountains was made by Ballard (1985), based on a BLH herbarium sheet of plants taken from Manitou Island in Keweenaw County, Michigan. *Viola palustris* subsp. *palustris* has been well documented from the high mountains of New Hampshire and Maine (Haines et al. 2011) but has not been found in the Great Lakes or Great Plains regions south of the international boundary. Con-

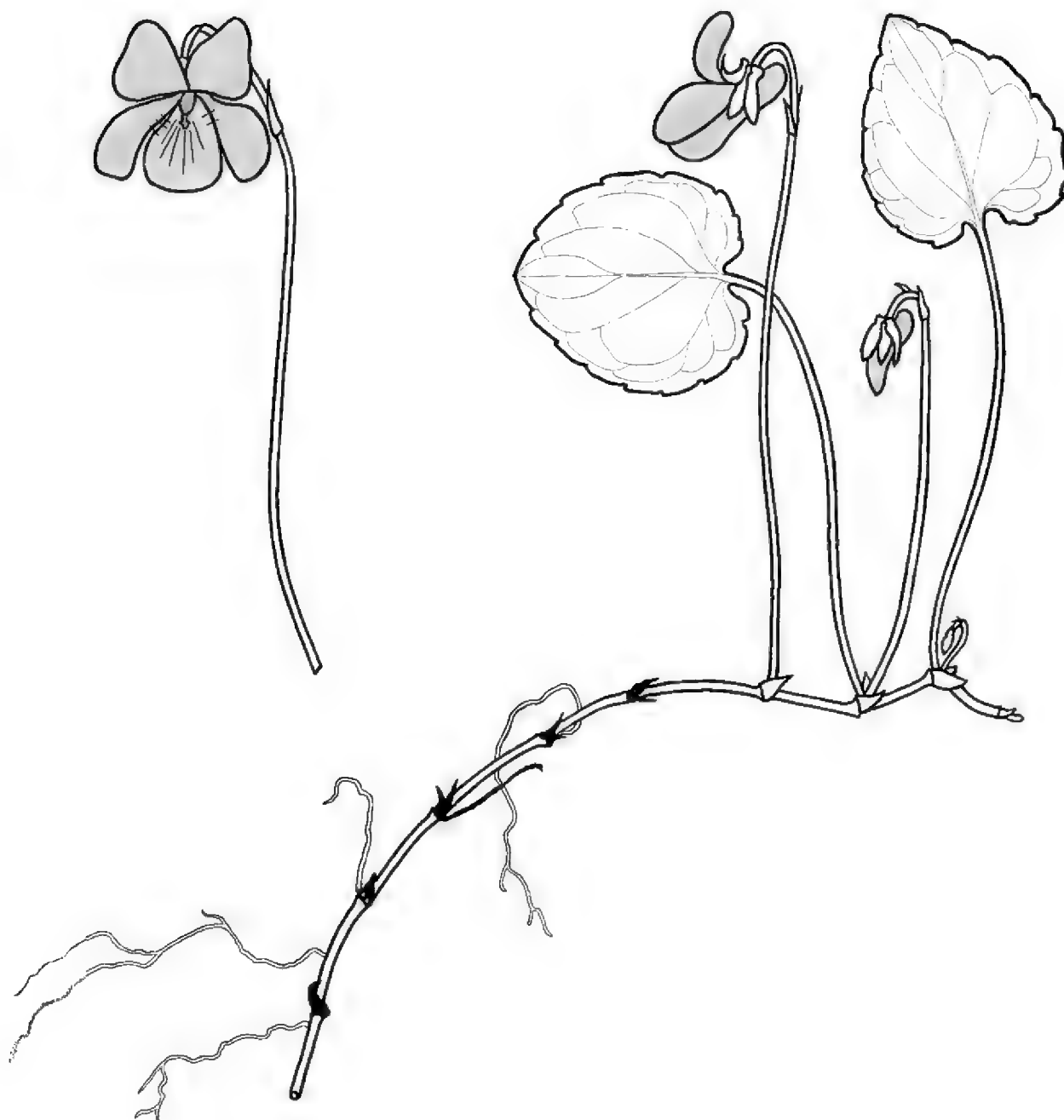


FIGURE 2. *Viola epipsila* subsp. *repens* in chasmogamous flower. Drawing by Kim Blaxland.

versely, *V. epipsila* has not been found in the eastern U.S. range of *V. palustris*. Both occur in central Canada, where they may co-occur.

Discussion. Two recently reidentified specimens at the University of Minnesota Herbarium (MIN) of *Viola epipsila* Ledeb. subsp. *repens* W.Becker, collected from Pennington Bog Scientific and Natural Area in Beltrami County in northern Minnesota, represent the second report of this violet south of the Canadian border in the eastern United States. These two collections were originally identified as *Viola pallens* (Banks ex Ging.) Brainerd. The Minnesota Department of Natural Resources' webpage (Minnesota DNR 2021) for the SNA describes the site as a "little-disturbed tract of . . . northern cedar swamp." Although the collections were made in 1979, the site presumably still harbors the species. What appears to be a somewhat dense *Thuja* swamp along Sucker Creek at the SNA, based on examination of the site using GoogleEarth (2022), is sim-

ilar in nature to numerous other sites in northern Minnesota. The species should be sought elsewhere in the region, especially in adjacent counties and in the northern two tiers of counties of Minnesota bordering Canada. Until the species has been documented in other areas of the state, Endangered status in Minnesota seems warranted.

Distinguishing *Viola epipsila* subsp. *repens* from *V. palustris* subsp. *palustris* in central and eastern North America is not especially difficult; the task is somewhat greater in western North America, where three or four “Palustres” taxa may co-occur. Hybridization among the “Palustres” violets is not rare (Sorsa 1968 and citations therein; Blaxland 2021) and is exacerbated by hybridization with other *Stolonosae*, particularly *Viola minuscula* Greene¹.

Diagnostic characters. Tetraploid *Viola epipsila* subsp. *repens* can be distinguished from the three octoploid North American taxa (*V. palustris* subsp. *brevipipes*, *V. palustris* subsp. *palustris*, and *V. pluviae*) in having 1–2 leaves (vs. (2)3–5 leaves) per rhizome or stolon, peduncular bracts usually positioned above the middle and often near the apex (vs. below the middle to slightly above it), abaxial surface of leaf blades commonly finely pubescent along veins (vs. leaf blades strictly glabrous), flower pale violet (vs. white, white with violet tinge, or pale violet), and lateral petals sparsely bearded (vs. glabrous) within.

Specimen citations. Minnesota, Beltrami County: Pennington Orchid Bog SNA [correct name: Pennington Bog Scientific and Natural Area], 1 mile north of Pennington, NW1/4 sec. 3, T 146N, R 30W, Stream edge [= Sucker Creek] in Cedar Bog, August 19, 1979, *Keller 9* (MIN 715630); *Keller 33* (MIN 715584).

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¹This is the species in eastern North America that has most recently been called *Viola mackloskeyi* F.E. Lloyd or sometimes *V. pallens* (Banks ex Ging.) Brainerd. However, recent unpublished research indicates that *Viola mackloskeyi* is restricted to western North America and that the best name available for the eastern populations is *V. minuscula* (see Marcussen et al. 2012; Ballard 2020; Ballard et al. 2022).

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BOOK REVIEW

Nathanael Pilla & Scott Namestnik. 2022. *Wildflowers of the Indiana Dunes National Park*. Indiana University Press, Bloomington. x + 447 pp., paperback \$35.00. ISBN 978-0253060-41-9; ebook \$34.99. ISBN 978-0253060-42-6.

At roughly 16,000 acres (6,475 hectares) the Indiana Dunes National Park (hereafter, the Park) contains high plant diversity for its relatively small size as a national park and is the most botanically rich area in the Great Lakes region of North America. Two ecotones account in part for this diversity; the transition between the western prairies and eastern deciduous forest, and the transition between southern and boreal floras. Another factor contributing to this high plant diversity is the unusually rich diversity of plant habitats, which are well described in the introductory portion of this book, *Wildflowers of the Indiana Dunes National Park* by Nathanael Pilla and Scott Namestnik. Not since the publication of Peattie's *Flora of the Indiana Dunes* (1930) has an up-to-date floral guide of the Indiana Dunes been published. Given the long history of national park wildflower guides, I looked forward to the publication of a modern field guide to the wildflowers of the Park. This excellent and useful volume fulfills that goal.

The authors of this book, as with any popular wildflower guide, had two principal decisions to make, what plants to include and how to arrange them. The authors highlight 169 plant species (which constitutes about 10% of the 1,698 native and nonnative (482) plants) known from the Park (Pavlovic et. al. in press). These represent common species that the visitor to the Park is likely to encounter and represent 59 plant families of which the largest is Asteraceae (40 species). Twenty-eight families are represented in this book by a single species. The treatment for each of the 169 species presents a morphological description, the bloom period, what plant communities it inhabits, species notes, an etymology of the scientific name, and, for most species, an account of one or more look-a-like species. The authors mention approximately 209 look-a-like species, which brings the number of species treated in this guide to a total of 378, or 22% of the total flora of the Park.

The book is divided into ten sections: an introduction, a brief history of the Indiana Dunes National Park, a lengthy discussion of how to use this guide, descriptions of the several plant communities found in the Park, and the core of the book, six sections of species treatments arranged by flower color. Flower color is a popular method for arranging plants in national park wildflower guides (e.g., Hammer 2014, Janke 1963), but others use plant families (e.g., Beidleman et al. 2000) or flowering season (e.g., Hutson et al. 2006). A nice touch is that these headings are uniquely colored for each flower color section. I was disappointed that white and green flowers had to be combined. Within each color section,

plants are arranged alphabetically by scientific genus and species names. The morphological descriptions of the plants are accurate and thorough. Descriptions of the look-a-likes are variable in their length but focus on the key distinguishing characteristics. The book ends with a glossary of technical terms, a list of recommended reading and references, and an index.

A couple of minor things about the format of the individual species entries frustrated me. First, the family name is in a font larger than that of the scientific name of the species, leading one to wonder if this was to emphasize the family names. Nowhere in the book is the novice wildflower enthusiast told that learning family characteristics, a tool too lengthy for this guide, can be an important short cut to identifying plants. Second, the common names which are given parenthetically after the scientific names, are bolded as if to emphasize the common names, even though the species are organized by their scientific binomial names. While common names have their perils in that many species can have the same common name, use of bold print for the common names may confuse the novice reader. Which name is the novice to learn?

The conversational nature of the text and interesting notes and etymologies help make this book accessible and entertaining to the general reader. The interested reader not only learns Latin and Greek in reference to the scientific names but also learns interesting mythological stories. However, in places this style leads to some inaccuracies in the text. Counter to standard editorial practice of defining terms on first use, the Doctrine of Signatures is mentioned in *Cardamine concatenata* without definition and then finally defined under *Eupatorium perfoliatum*. This minor problem could have been solved by referring the reader to the *Eupatorium perfoliatum* explanation where the doctrine is mentioned in the *Cardamine concatenata* treatment. A few times literary references are obscure as in the entry for *Angelica atropurpurea*, where the world of Malacandra is referred to without explanation. C. S. Lewis described this world where trees and mountains were tall and thin, like *Angelica*, in his science fiction *Space Trilogy* (1990). Nevertheless, this information is interesting and useful. For the general reader, another inadequacy is that several technical terms used in the species descriptions are not defined in the glossary, e.g., introgression, hibernaculum, sessile, hermaphrodite, tubercle, haustoria, and umbellets.

The high-quality photographs of the flowers and plants add greatly to the usefulness of this book so that the reader can recognize the characteristics described in the text. The photographs of the plant communities will help the reader to recognize the habitats they find in the Park. Pilla and Namestnik's "Wildflowers of the Indiana Dunes National Park" will be a popular and classic introductory guide to the wildflowers of this area of high plant diversity.

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BOOK REVIEW

Sarah Simblet. 2020. *Botany for the Artist*. Photography by Sam Scott-Hunter. DK, New York. 256 pp. hardcover \$40.00. ISBN: 978-1-4654-9428-3.

Learning to see more while looking

This beautifully illustrated book not only provides instruction in drawing plants, it also gives the reader a special kind of macrobotanical instruction, which emphasizes visible features and a different—that is, artistic—perception of plants. In the Foreword, the author explains that botany and art both require observational skills, that “[d]rawing is a powerful tool for both insight and our imagination. It is a direct and universal language, as old as mankind, from which the written word developed,” and that “there is a significant difference between looking and seeing.” In teaching and learning, drawing helps to articulate visual ideas and to form memories of visual features where words are simply inadequate.

Why learn the botany? It is because learning the structures of plants and their organization helps an artist to learn what the important visual elements are and how they work together to form the larger image (i.e., gestalt). This helps the artist working with plants much as understanding the anatomy of humans or animals helps artists implement their visual ideas about them as art work. This process also enables the artist to reach beyond accurate representation of a subject to the capture of images that show different ways of viewing them. Building on basic botanical information, this book extends beyond the coverage of botany and botanical drawing to explore deeper ways of looking at and seeing plants and even allows a deeper understanding of science in general. The profuse and excellent illustrations in this book—clearly a labor of love, give strong support to these objectives. The high quality printing adds to its cost but greatly enhances its instructional value.

To understand and fully utilize this book, it is important to look at its organization. It contains eight sections, each containing many subsections that cover a wide range of related topics. The first three sections, *The Art of Botany*, *Drawing Plants*, and *Diversity*, introduce the scope and aims of the book. They range beyond the drawing process itself to evoke deeper thinking along with drawing. This helps to prepare readers for the techniques and underlying ideas presented in the subsequent five sections.

The Art of Botany section briefly summarizes the historical development of the use of botany in art and the use of art in botany. It reviews some of the artistic styles used in different time periods and how images employing those styles were used for scientific documentation, for art, or for other purposes. It also provide glimpses into the development of the artistic technology involved and builds on the idea that plants are integral to civilization in ways that increasingly

go beyond their primeval nutritional value, for example medicinal and aesthetic purposes. This made it necessary to develop the techniques needed to produce illustrations for multiple purposes, including identification, scientific communication, teaching, and aesthetics. Learning about these developments helps one to recognize and articulate the goals of the artistic processes. The *Art of Botany* section shows how the capture of aesthetic elements has increasingly enabled year-round visualization and indoor enjoyment of plants and their many ephemeral forms. In a subsection called *Zen Composition*, the reader gets a glimpse of the movement toward capturing visual elements beyond accurate representation of forms to emphasize the aesthetic essence of plants, which necessarily draws on our intuitive perceptions. Another subsection, *Meditation*, introduces the reader to meditations on plants. Here, the author starts on a very important facet of the use of art, i.e., the use of images to invite deeper thinking and to evoke spiritual responses. This topic is represented by a huge developing scientific literature that is explained in depth elsewhere. Although beautiful plant imagery has been pursued by gardeners and artists to promote a feeling of well-being for many millennia, these principles can be employed in a wide range of contemporary applications, for example in healthcare settings where they can promote serenity and healing.

The *Drawing Plants* section introduces the basic tools needed to draw plants in engaging and easy-to-understand ways. It covers handling and storing a living specimen to maintain an accurate model, the simple tools needed, supplies, techniques, and other preparations necessary to produce the desired images. Several subsections engagingly illustrate the basic processes of making marks to establish form, creating depth perspective, and working with colors, which can be daunting for beginners. These simple instructions will help interested naturalists and teachers to overcome their hesitations and record their visual ideas. The *Drawing Plants* subsection titled *Masterclass: Illustrated letter, Nikolaus von Jacquin* shows a beautifully illustrated letter composed in 1792 by the Dutch botanist Nikolaus von Jacquin. It is a powerful example of the messages in this book. The drawings in the letter enabled von Jacquin to explain what he found in the New World tropics to another scientist in London. It strongly reinforces the old adage that a picture is worth a thousand words.

The *Diversity* section introduces readers to the range of organisms that are covered in this book. Notably, it treats botany in the traditional sense, which includes fungi, lichens, and such macroalgae as brown algae, which are not included in the Plant Kingdom in the modern five-kingdom classification. It also contains a helpful, simplified taxonomic diagram of the major groups of plants. This section is supported by an extensive series of attractive drawings and photographs that show the overall appearance (gestalt) of representative organisms from the major taxonomic groups without dwelling on the often microscopic characteristics that distinguish them. As a result, the taxonomic affiliations are easy to recognize in these illustrations, thereby demonstrating the power of good simplified illustrations. Taking a different approach, the *Master Class* subsection shows a painting of grassland plants titled *Great Piece of Turf* (1503) by Albrecht Dürer. The author notes that “[w]ith this painting, [Dürer] tells that the more closely we look at small, ordinary things, the greater and more extraordi-

nary they will become, that there are entire worlds to be discovered in small places and we needn't go far to reach them." A relevant aside here—Dürer, who is best known for his stark, tortured religious images, evokes senses of serenity and visual beauty in this illustration of plants, very different thinking from this artist. If botanical artistic thinking can bring out this spirit in Dürer, it can also do it elsewhere as needed.

Each of the last five sections—*Roots*; *Stems*; *Leaves*; *Flowers*; and *Fruits, Cones, and Seeds*—focus on specific plant organs; however, we will deal with them collectively. They provide helpful, engaging instructions for portraying these organs and for using the artistic tools and pigments for achieving those portrayals. As they guide deeper studies of these organs, these sections also cover many visible facets of basic botany that might not be presented in a basic botany course, even though they may be very useful in field observations. Each section introduces the artist to the wide variety of forms taken by those structures and how they work together to form the whole (gestalt). Likewise, the sections provide ideas for developing quick sketches focusing on the important visible parts. For example, the *Stems* section contains subsections titled *Strong Stems*, *Stem Buds*, *Bark*, and *Runners*, among others. It is of particular interest to see how complex subjects are handled. For example, after a single pine tree is developed with simplified instructions for drawing its parts, there is also an extended series of exercises using trees as part of a landscape and in developing compositions. Photos of a variety of leaves are shown along with corresponding drawings to illustrate how they can be presented, including different perspectives and painting colors in leaves. Flowers hold a special interest for all viewers and are well represented here. The amazing diversity of flower parts, shapes, and arrangements from bud to full bloom is treated. The presentation of the pine cone is particularly satisfying in the way it simplifies observing and drawing what appears at first to be a complicated structure.

The *Preparatory Drawings* and *Drawing Class* subsections provide special instructions on the techniques needed for these special structures. The *Drawing Class* subsections contain suggestions for drawing the particular structures and perspectives featured in the sections to which they pertain. Often, several *Drawing Class* subsections are presented within a single section, each discussing different aspects of plant structure related to that section, for example, subsections on watermelon and pine cone in the *Fruits, Cones, and Seeds* section. In addition, there are special related subsections titled *Study* and *Masterclass*. The *Study* subsections discuss special aspects of particular plant parts that need careful observation. These exercises engage cognitive processes that develop artistic thinking coupled with observation and related activities, such as looking for patterns or appreciating some engaging artistic feature. The *Masterclass* subsections illustrate the ways that artistic masters handle these subjects.

Where do traditional film photography and now digital image capture fit into botanical art? Photography can instantly record image details far beyond what manual artistry can do. Not only that, but photographers can also produce very pleasing and artistic images by working with composition, exposure, and other techniques as is well illustrated in this book. On the other hand, although photography will continue to be very important, it is not well suited for simplifying

images, emphasizing key features, and bringing out, or enhancing, artistic elements that the trained human mind can perceive and show very effectively through art.

The idea of engaged observation or perception (the *seeing* noted in the subtitle of this review) also relates to education. In the now distant past, drawing what one observed was an integral part of biology lab instruction. As a student and later as a teacher, one of us (LDN) saw high value in these exercises. But apprehension by both students and teachers about their lack of artistic skill often creates a barrier. This can be mitigated, if not overcome, by assuring students that their work will not be graded on artistic skill. The aim of the drawing exercise is to capture the main elements of the forms that are observed to create more complete and durable memories. This not only achieves the goal of familiarizing observers with the subjects, it also starts them on the path of different ways of seeing and recording their insights, much like learning a new language.

Because this book goes beyond merely manual artistic instruction, it will inspire greater engagement with nature or, as the author expresses it, seeing more while looking. Indeed, this book opens opportunities not only for aspiring artists, but also for those who simply enjoy being out in nature (even urban pockets of nature) and for those with a lot of biological education. For many, this will lead into deeper scientific and artistic engagement. However, the perceptions developed as a result of deeper engagement with nature also promote conservation through a greater appreciation of nature and its environmental values. For example, consider Aldo Leopold's words in his classic *A Sand County Almanac*: "Our ability to perceive quality in nature begins, as in art, with the pretty. It expands through successive stages of the beautiful to values as yet uncaptured by language." As a result of the many interesting and useful perspectives opened up by this broad coverage, this book about botany for artists also offers art for botanists and others seeking the beauty of nature.

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